S.I.A.

REPORT

OF THE

THIRTY-EIGHTH MEETING

OF THE

BRITISH MUSEUM NATURAL HISTORY BRANCH

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT

NORWICH IN AUGUST 1868.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1869.

PRINTED BY

TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

ALERE FLAMMAM.

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OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are,—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another, and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

ADMISSION OF MEMBERS AND ASSOCIATES.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions, shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee, shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

COMPOSITIONS, SUBSCRIPTIONS, AND PRIVILEGES.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this Subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

Associates for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.

2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.

3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]

4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]

5. Associates for the year, subject to the payment of One Pound.

6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members who have not intermitted their Annual Subscription.

2. *At reduced or Members' Prices*, viz. two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain*, at one-third of the Publication Price. Application to be made (by letter) to Messrs. Taylor & Francis, Red Lion Court, Fleet St., London.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

MEETINGS.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee at the previous Meeting; and the Arrangements for it shall be entrusted to the Officers of the Association.

GENERAL COMMITTEE.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

1. Presidents and Officers for the present and preceding years, with authors of Reports in the Transactions of the Association.

2. Members who have communicated any Paper to a Philosophical Society, which has been printed in its Transactions, and which relates to such subjects as are taken into consideration at the Sectional Meetings of the Association.

3. Office-bearers for the time being, or Delegates, altogether not exceeding three in number, from any Philosophical Society publishing Transactions.

4. Office-bearers for the time being, or Delegates, not exceeding three, from Philosophical Institutions established in the place of Meeting, or in any place where the Association has formerly met.

5. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing for the Meeting of the year by the President and General Secretaries.

6. The Presidents, Vice-Presidents, and Secretaries of the Sections are *ex-officio* members of the General Committee for the time being.

SECTIONAL COMMITTEES.

The General Committee shall appoint, at each Meeting, Committees, consisting severally of the Members most conversant with the several branches of Science, to advise together for the advancement thereof.

The Committees shall report what subjects of investigation they would particularly recommend to be prosecuted during the ensuing year, and brought under consideration at the next Meeting.

The Committees shall recommend Reports on the state and progress of particular Sciences, to be drawn up from time to time by competent persons, for the information of the Annual Meetings.

COMMITTEE OF RECOMMENDATIONS.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects, shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee, unless previously recommended by the Committee of Recommendations.

LOCAL COMMITTEES.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

OFFICERS.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer, shall be annually appointed by the General Committee.

COUNCIL.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

PAPERS AND COMMUNICATIONS.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

ACCOUNTS.

The Accounts of the Association shall be audited annually, by Auditors appointed by the Meeting.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S. L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, F.R.S., Astronomer Royal, &c. John Dalton, D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, F.L.S., &c. Wm. Hutton, F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	Marquis of Northampton. Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount Edgecumbe.	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir D. T. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	Earl of Listowel. Viscount Adare Sir W. R. Hamilton, Pres.R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.

SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. Professor Powell, F.R.S.	Henry Clark, M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. DelaBeche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's.	Matthew Moggridge, Esq. D. Nicol, M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrew EDINBURGH, July 21, 1850.	Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S.L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L. F.R.S. The Earl of Rosse, M.R.I.A., Pres. R.S. Sir Henry T. DelaBeche, F.R.S Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, M.D. Professor W. P. Wilson.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., & Pres. Camb. Phil. Society. HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Philos. Society. William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, M.D., V.P. Hull. Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S.L. & E., F.R.A.S. Joseph Brooks Yates, F.S.A., F.R.G.S.	Joseph Dickinson, M.D., F.R.S. Thomas Inman, M.D.
The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S. L. & E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint Professor William Thomson, M.A., F.R.S.	John Strang, LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford. CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugall, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S. L. & E., V.P.R.I.A. DUBLIN, August 26, 1857.	The Right Honourable the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq. Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, LL.D.
RICHARD OWEN, M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural-History Departments of the British Museum. LEEDS, September 22, 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.
HIS ROYAL HIGHNESS THE PRINCE CONSORT. ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen.	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.

The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.I.C.E. Joseph Whitworth, Esq., F.R.S., M.I.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, M.A., Esq. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle. Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Reverend the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq. F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Reverend the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M.P. J. T. Chance, Esq. F. Osler, Esq., F.R.S. The Rev. Charles Evans, M.A.	William Mathews, Esq., jun., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.
WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. NOTTINGHAM, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, M.D., F.R.S., F.L.S. John Russell Hinds, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. DUNDEE, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh. James D. Forbes, LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonards, University of St. Andrews	J. Henderson, Esq., jun. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk. Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge. Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge. Thomas Brightwell, Esq.	Dr. Donald Dalrymple, M.P. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. The Earl of Devon The Right Hon. Sir Stafford H. Northcote, C.B., Bart., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S. John C. Bowring, Esq. The Rev. R. Kirwan.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
MATHEMATICAL AND PHYSICAL SCIENCES.		
COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.		
1832. Oxford	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.
SECTION A.—MATHEMATICS AND PHYSICS.		
1835. Dublin	Rev. Dr. Robinson	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol	Rev. William Whewell, F.R.S.	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S.	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow	Prof. Forbes, F.R.S.	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth	Rev. Prof. Lloyd, F.R.S.	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork	Prof M'Culloch, M.R.I.A.	J. Nott, Prof. Stevelly.
1844. York	The Earl of Rosse, F.R.S.	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford	Rev. Prof. Powell, M.A., F.R.S.	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich	Rev. W. Whewell, D.D., F.R.S., &c.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast	Prof. W. Thomson, M.A., F.R.S. L. & E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull	The Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow	Rev. Prof. Kelland, M.A., F.R.S. L. & E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.

Date and place.	Presidents.	Secretaries.
1857. Dublin	Rev. T. R. Robinson, DD., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.
1859. Aberdeen ...	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. Smith, Prof. Stevelly.
1860. Oxford	Rev. B. Price, M.A., F.R.S.	Rev. G. C. Bell, Rev. T. Rennison, Prof. Stevelly.
1861. Manchester .	G. B. Airy, M.A., D.C.L., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1862. Cambridge .	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle...	Prof. W. J. Macquorn Rankine, C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S., F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson.
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee......	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. C. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S....	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford	John Dalton, D.C.L., F.R.S.......	James F. W. Johnston.
1833. Cambridge..	John Dalton, D.C.L., F.R.S.......	Prof. Miller.
1834. Edinburgh .	Dr. Hope..............................	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol	Rev. Prof. Cumming...............	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle...	Rev. William Whewell, F.R.S. ...	Prof. Miller, R. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Golding Bird, M.D., Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S. ...	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S................	J. Prideaux, Robert Hunt, W. M. Tweedy.
1842. Manchester.	John Dalton, D.C.L., F.R.S.......	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork	Prof. Apjohn, M.R.I.A.	R. Hunt, Dr. Sweeny.
1844. York	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge .	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt., Prof. Solly.

Date and Place.	Presidents.	Secretaries.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S..........	R. Hunt, G. Shaw.
1850. Edinburgh .	Dr. Christison, V.P.R.S.E.	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S. ...	T. J. Pearsall, W. S. Ward.
1852. Belfast	Thomas Andrews, M.D., F.R.S. .	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool...	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S. .	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S..........	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen ...	Dr. Lyon Playfair, C.B., F.R.S. .	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford	Prof. B. C. Brodie, M.A., F.R.S. .	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester .	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge .	Prof. W. A. Miller, M.D., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle...	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath	W. Odling, M.B., F.R.S., F.C.S..	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S. ...	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee......	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich ...	Prof. E. Frankland, F.R.S., F.C.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge..	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh..	Prof. Jameson	Prof. Phillips, T. Jameson Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol	Rev. Dr. Buckland, F.R.S.—*Geography.* R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geography.* G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography.* Captain H. M. Denham, R.N.
1838. Newcastle..	C. Lyell, F.R.S., V.P.G.S.—*Geography.* Lord Prudhope.	W. C. Trevelyan, Capt. Portlock.—*Geography.* Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geography.* G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.

Date and Place.	Presidents.	Secretaries.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, Hugh Murray, H. E. Strickland, John Scoular, M.D.
1841. Plymouth ..	H. T. De la Beche, F.R.S.	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork	Richard E. Griffith, F.R.S., M.R.I.A.	Francis M. Jennings, H. E. Strickland.
1844. York	Henry Warburton, M.P., Pres. Geol. Soc.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge .	Rev. Prof. Sedgwick, M.A., F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton	Leonard Horner, F.R.S.—*Geography*. G. B. Greenough, F.R.S.	Robert A. Austen, J. H. Norten, M.D., Prof. Oldham.—*Geography*. Dr. C. T. Beke.
1847. Oxford	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, C.B., F.R.S.	Starling Benson, Prof. Oldham, Prof. Ramsay.
1849. Birmingham	Sir Charles Lyell, F.R.S., F.G.S.	J. Beete Jukes, Prof. Oldham, Prof. A. C. Ramsay.
1850. Edinburgh *	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Professor Nicol.

SECTION C.—GEOLOGY.

1851. Ipswich ...	William Hopkins, M.A., F.R.S...	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast......	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull.........	Prof. Sedgwick, F.R.S.	Prof. Harkness, William Lawton.
1854. Liverpool ..	Prof. Edward Forbes, F.R.S. ...	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S.	James Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S.	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin......	The Lord Talbot de Malahide ...	Prof. Harkness, Gilbert Sanders, Robert H. Scott.
1858. Leeds	William Hopkins, M.A., LL.D., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford......	Rev. Prof. Sedgwick, LL.D., F.R.S., F.G.S.	Prof. Harkness, Edward Hull, Capt. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S., &c.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.......	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle...	Prof. Warington, W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.

* At the Meeting of the General Committee held in Edinburgh, it was agreed "That the subject of Geography be separated from Geology and combined with Ethnology, to constitute a separate Section, under the title of the "Geographical and Ethnological Section," for Presidents and Secretaries of which see page xxxi.

Date and place.	Presidents.	Secretaries.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S., F.G.S.	Edward Hull, W. Pengelly, Henry Woodward.
1868. Norwich ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford......	Rev. P. B. Duncan, F.G.S.	Rev. Prof. J. S. Henslow.
1833. Cambridge*	Rev. W. L. P. Garnons, F.L.S....	C. C. Babington, D. Don.
1834. Edinburgh	Prof. Graham........................	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin......	Dr. Allman..........................	J. Curtis, Dr. Litton.
1836. Bristol......	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart................	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S..................	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth	John Richardson, M.D., F.R.S....	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork.........	William Thompson, F.L.S.	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York	Very Rev. The Dean of Manchester	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S.	Dr. Lankester, T. V. Wollaston.
1846. Southamptn	Sir J. Richardson, M.D., F.R.S...	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford......	H. E. Strickland, M.A., F.R.S....	Dr. Lankester, Dr. Melville, T. V. Wollaston.

SECTION D.—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see pp. xxx, xxxi.]

1848. Swansea ...	L. W. Dillwyn, F.R.S.	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh ..	Prof. Goodsir, F.R.S. L. & E. ...	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich......	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.

* At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. xxx.

Date and Place.	Presidents.	Secretaries.
1853. Hull	C. C. Babington, M.A., F.R.S....	Robert Harrison, Dr. E. Lankester.
1854. Liverpool ...	Prof. Balfour, M.D., F.R.S.......	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E. ...	William Keddie, Dr. Lankester.
1856. Cheltenham.	Thomas Bell, F.R.S., Pres. L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds.........	C. C. Babington, M.A., F.R.S. ...	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen ...	Sir W. Jardine, Bart., F.R.S.E. .	Prof. Dickie, M.D, Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford	Rev. Prof. Henslow, F.L.S.	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester .	Prof. C. C. Babington, F.R.S. ...	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge ..	Prof. Huxley, F.R.S................	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle ...	Prof. Balfour, M.D., F.R.S.......	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath	Dr. John E. Gray, F.R.S.	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham	T. Thomson, M.D., F.R.S.	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D.—BIOLOGY*.

1866. Nottingham.	Prof. Huxley, LL.D, F.R.S.—*Physiological Dep.* Prof. Humphry, M.D., F.R.S.—*Anthropological Dep.* Alfred R. Wallace, F.R.G.S.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee	Prof. Sharpey, M.D., Sec. R.S.—*Dep. of Zool. and Bot.* George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S.—*Dep. of Physiology.* W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Tawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEES OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge .	Dr. Haviland	Dr. Bond, Mr. Paget.
1834. Edinburgh ..	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E. (UNTIL 1847.)—ANATOMY AND MEDICINE.

1835. Dublin	Dr. Pritchard..........................	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool ...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle ...	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S.	Dr. G. O. Rees, F. Ryland.

* At the Meeting of the General Committee at Birmingham, it was resolved:—"That the title of Section D be changed to Biology;" and "That for the word 'Subsection' in the rules for conducting the business of the Sections, the word 'Department' be substituted."

Date and Place.	Presidents.	Secretaries.
1840. Glasgow	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof. Reid.
1841. Plymouth	P. M. Roget, M.D., Sec. R.S.	Dr. J. Butter, J. Fuge, Dr. R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. Sargent.
1843. Cork	Sir James Pitcairn, M.D.	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.

SECTION E.—PHYSIOLOGY.

1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton	Prof. Owen, M.D., F.R.S.	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford*	Prof. Ogle, M.D., F.R.S.	Dr. Thomas, K. Chambers, W. P. Ormerod.

PHYSIOLOGICAL SUBSECTIONS OF SECTION D.

1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir Benjamin Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen	Prof. Sharpey, M.D., Sec. R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford	Prof. G. Rolleston, M.D., F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S.L. & E.	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge	C. E. Paget, M.D.	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath	Dr. Edward Smith, LL.D., F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birmingham	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. xxvii.]

ETHNOLOGICAL SUBSECTIONS OF SECTION D.

1846. Southampton	Dr. Pritchard	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A.	Prof. Buckley.
1848. Swansea		G. Grant Francis.
1849. Birmingham		Dr. R. G. Latham.
1850. Glasgow	Vice-Admiral Sir A. Malcolm	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

1851. Ipswich	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.

* By direction of the General Committee at Oxford, Sections D and E were incorporated under the name of "Section D—Zoology and Botany, including Physiology" (see p. xxix). The Section being then vacant was assigned in 1851 to Geography.

Date and Place.	Presidents.	Secretaries.
1856. Cheltenham.	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin	Rev. Dr. J. Henthawn Todd, Pres. R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds.........	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, Francis Galton, P. O'Callaghan, Dr. Norton Shaw, Thomas Wright.
1859. Aberdeen ...	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Professor Geddes, Dr. Norton Shaw.
1860. Oxford	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lempriere, Dr. Norton Shaw.
1861. Manchester .	John Crawfurd, F.R.S.	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge ..	Francis Galton, F.R.S.	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle ...	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir R. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham.	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich ...	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, C. R. Markham, T. Wright.

STATISTICAL SCIENCE.

COMMITTEES OF SCIENCES, VI.—STATISTICS.

1833. Cambridge .	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh .	Sir Charles Lemon, Bart.	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Charles Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool ...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle ...	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Rt. Hon. Lord Sandon, F.R.S., M.P.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth ...	Lieut.-Col. Sykes, F.R.S.	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester .	G. W. Wood, M.P., F.L.S.	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P.	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge ..	Rt. Hon. The Earl Fitzwilliam...	J. Fletcher, W. Cooke Tayler, LL.D.
1846. Southampton	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S. ...	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.

Date and Place.	President.	Secretaries.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S.	J. Fletcher, Capt. R. Shortrede.
1849. Birmingham	Rt. Hon. Lord Lyttelton	Dr. Finch, Prof. Hancock, F. G. P. Neison.
1850. Edinburgh..	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich......	Sir John P. Boileau, Bart.	J. Fletcher, Prof. Hancock.
1852. Belfast	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, Jun.
1853. Hull	James Heywood, M.P., F.R.S....	Edward Cheshire, William Newmarch.
1854. Liverpool ...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow	R. Monckton Miles, M.P..........	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

1856. Cheltenham	Rt. Hon. Lord Stanley, M.P. ...	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock Newmarch, W. M. Tartt.
1857. Dublin	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds.........	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen ...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Rev. Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S.	David Chadwick, Prof. R. C. Christie, E. Macrory, Rev. Prof. J. E. T. Rogers.
1862. Cambridge..	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle ...	William Tite, M.P., F.R.S.	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath..........	William Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers...............	R. Birkin, Jun., Prof. Leone Levi, E. Macrory.
1867. Dundee......	M. E. Grant Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich ...	Samuel Brown, Pres. Instit. Actuaries.	Rev. W. C. Davie, Prof. Leone Levi.

MECHANICAL SCIENCE.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol	Davies Gilbert, D.C.L., F.R.S....	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool ...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle ...	Charles Babbage, F.R.S.	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robert Stephenson.	W. Carpmael, William Hawkes, Thomas Webster.
1840. Glasgow ...	Sir John Robinson..................	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth...	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester.	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.

Date and Place.	President.	Secretaries.
1843. Cork	Prof. J. Macneill, M.R.I.A.	James Thomson, Robert Mallet.
1844. York	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S.	Rev. W. T. Kingsley.
1846. Southampton	Rev. Prof. Willis, M.A., F.R.S.	William Betts, Jun., Charles Manby.
1847. Oxford	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robert Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. Dr. Robinson	Dr. Lees, David Stevenson.
1851. Ipswich	William Cubitt, F.R.S.	John Head, Charles Manby.
1852. Belfast	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, C.E., F.R.S.	James Oldham, J. Thomson, W. Sykes Ward.
1854. Liverpool	John Scott Russell, F.R.S.	John Grantham, J. Oldham, J. Thomson.
1855. Glasgow	W. J. Macquorn Rankine, C.E., F.R.S.	L. Hill, Jun., William Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, Jun., H. M. Jeffery.
1857. Dublin	The Right Hon. The Earl of Rosse, F.R.S.	Prof. Downing, W. T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S.	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S.	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge	William Fairbairn, LL.D., F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P.Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. A. Tarbottom.
1867. Dundee	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE GENERAL TREASURER'S ACCOUNT from 4th September 1867 (DUNDEE) to 19th August 1868 (NORWICH).

RECEIPTS.

	£	s.	d.	£	s.	d.
To Balance brought from last Account				314	10	5
Received for Life Compositions at Dundee Meeting and since				279	0	0
,, Annual Subscriptions, ditto ditto				620	0	0
,, Associates' Tickets, ditto ditto				1158	0	0
,, Ladies' Tickets, ditto ditto				771	0	0
,, Dividends on Stock				248	12	6
,, Sale of Publications—viz.						
Reports	23	6	9			
Index, Catalogue of Stars, &c.	27	1	1			
				50	7	10
				£3441	10	9

Examined and found correct, December 4, 1868.

WILLIAM ODLING, }
W. H. FLOWER, } *Auditors.*

PAYMENTS.

	£	s.	d.	£	s.	d.
By paid Expenses of Dundee Meeting, also Sundry Printing, Binding, Advertising, and Incidental Petty Expenses				292	12	5
,, Printing, Engraving, and Binding Report of 36th Meeting (Nottingham)				681	16	9
,, Salaries (1 year)				350	0	0
,, Grants made at Dundee Meeting, viz.—						
Maintaining Establishment of Kew Observatory	£600	0	0			
Lunar Committee	120	0	0			
Metrical Committee	50	0	0			
Zoological Record	100	0	0			
Committee on Kent's Hole Explorations	150	0	0			
,, Steamship Performance	100	0	0			
,, British Rainfall	50	0	0			
,, Luminous Meteors	50	0	0			
,, Organic Acids	60	0	0			
,, Fossil Crustacea	25	0	0			
,, Methyl Series	25	0	0			
,, Mercury and Bile	25	0	0			
,, Organic Remains in Limestone Rocks	25	0	0			
,, Scottish Earthquakes	20	0	0			
,, Fauna—Devon and Cornwall	30	0	0			
,, British Fossil Corals	50	0	0			
,, Bagshot Leaf-Beds	50	0	0			
,, Greenland Explorations	100	0	0			
,, Fossil Flora	25	0	0			
,, Tidal Observations	100	0	0			
,, Underground Temperature	50	0	0			
,, Spectroscopic Investigations of Animal Substances	5	0	0			
,, Secondary Reptiles &c.	30	0	0			
,, British Marine Invertebrate Fauna	100	0	0			
				1940	0	0
1868. Aug. 19. Balance at London and Westminster Bank	£173	19	10			
,, in hands of General Treasurer	3	1	9			
				177	1	7
				£3441	10	9

W. SPOTTISWOODE,
August 19, 1868.

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Henry S. Ellis, Esq., F.R.A.S.
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LOCAL TREASURER FOR THE MEETING AT EXETER.

William Cotton, Esq.

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Tyndall, Professor, F.R.S.
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Professor Phillips, M.A., D.C.L.
William R. Grove, Esq., F.R.S.
The Duke of Buccleuch, K.B.

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Dr. Thomas Thomson, F.R.S., Kew.

ASSISTANT GENERAL SECRETARY.

George Griffith, Esq., M.A., 1 Woodside, Harrow.

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William Spottiswoode, Esq., M.A., F.R.S., F.R.G.S., 50 Grosvenor Place, London, S.W.

AUDITORS.

Dr. Odling, F.R.S. W. H. Flower, Esq., F.R.S. Professor G. C. Foster, F.C.S.

OFFICERS OF SECTIONAL COMMITTEES PRESENT AT THE NORWICH MEETING.

SECTION A.—MATHEMATICS AND PHYSICS.

President.—Professor Tyndall, LL.D, F.R.S.
Vice-Presidents.—J. P. Gassiot, F.R.S.; Rev. Canon Heaviside; Rev. Professor Bartholomew Price, M.A., F.R.S.; Rev. C. Pritchard, M.A., F.R.S.; Professor H. J. S. Smith, M.A., F.R.S.; Professor Stokes, D.C.L., Sec. R.S.; Rev. Professor Willis, M.A., F.R.S.
Secretaries.—Professor G. C. Foster; Rev Robert Harley, F.R.S.; R. B. Hayward, M.A.

SECTION B.—CHEMISTRY AND MINERALOGY, INCLUDING THEIR APPLICATIONS TO AGRICULTURE AND THE ARTS.

President.—Professor Edward Frankland, F.R.S., F.C.S.
Vice-Presidents.—Dr. J. H. Gladstone, F.R.S.; Professor Liveing, F.C.S.; Professor Odling, F.R.S.; Dr. Stenhouse, F.R.S.; Professor Williamson, F.R.S.
Secretaries.—Dr. A. Crum Brown, F.R.S.E., F.C.S.; Dr. W. J. Russell, F.C.S.; F. Sutton, F.C.S.

SECTION C.—GEOLOGY.

President.—R. A. C. Godwin-Austen, F.R.S., F.G.S.
Vice-Presidents.—Sir Chas. J. F. Bunbury, Bart., F.R.S., F.G.S.; John Evans, F.R.S., F.G.S.; R. Fitch, F.G.S.; Professor Harkness, F.R.S.; Professor Huxley, F.R.S.; Sir Charles Lyell, Bart., D.C.L., F.R.S.; Professor Phillips, D.C.L., F.R.S., F.G.S.; Warington W. Smyth, F.R.S., F.G.S.
Secretaries.—W. Pengelly, F.R.S.; Rev. H. H. Winwood, M.A., F.G.S.; Rev. J. Gunn, F.G.S.; Rev. Osmund Fisher, M.A., F.G.S.

SECTION D.—BIOLOGY.

President.—Rev. M. J. Berkeley, M.A., F.L.S.
Vice-Presidents.—Professor Balfour, M.D., F.R.S.; George Bentham, F.R.S.; George Busk, F.R.S.; W. H. Flower, F.R.S.; Professor Humphry, F.R.S.; Professor Newton, M.A., F.L.S.; Professor Rolleston, F.R.S.; E. B. Tylor, F.L.S.
Secretaries.—G. W. Firth; M. Foster, M.D., F.L.S.; Professor Lawson, M.A.; H. T. Stainton, F.R.S.; Rev. H. B. Tristram, LL.D., F.R.S.; Professor E. Perceval Wright, M.D., F.L.S.; T. S. Cobbold, M.D., F.R.S.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

President.—Capt. G. H. Richards, R.N., F.R.S., Hydrographer to the Admiralty.
Vice-Presidents.—Vice-Admiral Sir Edward Belcher; Sir Walter Elliot; Sir F. Leopold M^{c}Clintock, F.R.S.; Sir Charles Nicholson, Bart.; Admiral Erasmus Ommanney, F.R.S.; Sir Arthur Phayre; General Sir A. Scott Waugh, F.R.S.
Secretaries.—H. W. Bates, Assist. Sec. R.G.S.; Thomas Baines, F.R.G.S.; Clements R. Markham, Sec. R.G.S.; T. Wright, Sec. Ethnological Society.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

President.—Samuel Brown, President of the Institute of Actuaries.
Vice-Presidents.—Sir Willoughby Jones, Bart.; Sir Samuel Bignold, Knt.; Sir John Bowring, F.R.S.; Dr. Farr, F.R.S.; W. Newmarch, F.R.S.; R. J. H. Harvey, M.P.; James Heywood, M.A., F.R.S.
Secretaries.—Professor Leone Levi, F.S.A.; Rev. W. Cufaude Davie, M.A.

SECTION G.—MECHANICAL SCIENCE.

President.—G. P. Bidder, F.R.G.S.
Vice-Presidents.—J. F. Bateman, F.R.S.; Admiral Sir Edward Belcher, K.C.B.; William Fairbairn, LL.D., F.R.S.; C. Hutton Gregory, Pres. Inst. C.E.; T. Hawksley, C.E.; James Nasmyth, F.R.S.; Professor W. J. Macquorn Rankine, LL.D., F.R.S.; C. Vignoles, F.R.S.; J. Whitworth, LL.D., F.R.S.; Rev. Professor Willis, F.R.S.
Secretaries.—P. Le Neve Foster, M.A.; Charles Manby, F.R.S.; J. F. Iselin, M.A.; William Smith, C.E.

Report of the Council of the British Association, presented to the General Committee, Wednesday, August 19, 1868.

The Council have received Reports from the General Treasurer, and from the Kew Committee at each of their Meetings, and their Reports for the past year will be laid before the General Committee.

Owing to the death of Lord Wrottesley, the Chairman and most active member of the Parliamentary Committee, no Report of this Committee is presented this year.

At their Meeting on March 14th, Mr. F. Galton, General Secretary, informed the Council that considerations of health precluded him, to his sincere regret, from continuing to hold office. The Council, in accordance with their previous practice, appointed a Committee, consisting of the General Secretaries and the gentlemen who had formerly filled that office, for the purpose of reporting a recommendation to the Council of a successor to Mr. Galton. From this Committee the Council have received the following Report:—"Resolved that Dr. T. Thomson, F.R.S., &c., be recommended as highly qualified for election as Joint-General Secretary of the Association." The Council recommend that Dr. T. Thomson be now elected Joint-General Secretary.

At the last Meeting of the Association the General Committee referred to the Council a Resolution relating to the administration of the Natural-History Collections of the British Museum, in which it was recommended to press on the Government the importance of transferring the control of these Collections from the Board of Trustees to a single officer of Government responsible to Parliament. After deliberating on the Report of a Committee specially appointed to consider the question, the Council sent a deputation to urge on the Government the desirability of making the proposed changes.

Professor Martins, of Montpellier, and Professor Mannheim, of Paris, who attended the Meeting of the Association at Dundee, have been elected Corresponding Members by the Council.

The Annual Report of the Association for last year has been issued in an improved form and at an earlier date than usual. It is hoped that with the cooperation of the Authors of Reports it may in future be published at a still earlier period, and thereby its utility much increased.

Owing to the modifications made at the Birmingham Meeting, in the arrangements of Section D, the Council have had under consideration the advisability of omitting the word "Ethnology" in the designation of Section E. They recommend that a Resolution to this effect be passed by the General Committee.

The Council have been informed that invitations for 1869 will be presented by Deputations from Exeter, Liverpool, Edinburgh, and Brighton;—and an invitation for the following year, by a Deputation from Bradford.

Report of the Kew Committee of the British Association for the Advancement of Science for 1867–68.

The Committee of the Kew Observatory submit to the Council of the British Association the following statement of their proceedings during the past year:—

The Meteorological Office, to which allusion was made in the last Report, continues in operation, Kew being the Central Observatory as arranged with the Meteorological Committee appointed by the Council of the Royal Society In consequence of this arrangement there has been during the past year a considerable access of work to the Kew Observatory, and the duties undertaken by that establishment may, as in the last Report, for clearness' sake, be again considered under the two following heads:—

(A) The work done by the Kew Observatory under the Direction of the British Association.

(B) That done at Kew as the Central Observatory of the Meteorological Committee.

This system of division will therefore be adopted in this Report; but it ought to be mentioned that the financial statement appended to it refers only to the first of these divisions, since the work done at Kew for the Meteorological Committee has been paid from funds supplied by the Committee, and not in any way from money subscribed by the British Association.

(A) Work done by Kew Observatory under the Direction of the British Association.

1. *New Instruments for Colaba Observatory.*—The Chairman of the Kew Committee, shortly after the Meeting at Dundee, received a communication from Mr. Chambers, the Superintendent of the Colaba Observatory, Bombay, requesting the support of the Kew Committee in his application to the India Board for a supply of Self-recording Magnetographs and other instruments required for his observatory. This was ultimately brought before the Council of the British Association; and in consequence of the steps taken, Sir Stafford Northcote, in a letter to General Sabine, dated 30 January, 1868, sanctioned the supply of new instruments for the observatory at Bombay, while General Sabine, on behalf of the Kew Committee, undertook to select the following instruments required:—

(1) A set of Self-recording Magnetometers for registering by photography changes of Declination, Horizontal Force, and Vertical Force.

(2) Thomson's Electrometer, arranged for photographic self-registration.

(3) A Self-recording Barograph and Thermograph, of the pattern adopted by the Meteorological Committee (added afterwards).

(4) Apparatus for measuring and tabulating the curves given by the above-named instruments.

(5) Photographic apparatus, porcelain dishes, and boxes for paper and photograms.

(6) Moffat's Ozonometer, in box with clockwork and rotating cylinder.

(7) Beam-compasses, with steel points and tangent screw adjustment to measure 4 feet (for verification of distances in deflection experiments).

(8) Rotating frame with large glass jar for testing thermometers.

2. *Magnetic work.*—The Self-recording Magnetographs, ordered by the

India Board for Mr. Chambers, have been verified at Kew, and returned to the India Office, from which they have been doubtless despatched ere this to Bombay.

A Differential Declinometer (received from General Sabine's Office) has been verified at Kew for Dr. Lemström, who has gone out as physical observer with the Spitzbergen expedition.

A Unifilar has been received at Kew for Mr. Meldrum, of the Mauritius Observatory, and its constants are in progress of being determined.

Senhor Viegas, of Coimbra, and Lieutenant Ielagin, of the Imperial Russian Navy, have received magnetic instruction at Kew; and a Dip-circle has been prepared for the latter gentleman, who purposes making observations with it at the various European Observatories.

The usual monthly absolute determinations of the magnetic elements continue to be made by Mr. Whipple, magnetic assistant; and the Self-recording Magnetographs are in constant operation as heretofore, also under Mr. Whipple, who has displayed much care and ability in the discharge of his duties.

The photographic department connected with the Self-recording instruments is under the charge of Mr. Page, assisted by Mr. Foster, both of whom discharge their duties very satisfactorily.

An arrangement connected with the instrumental clock for shutting off the light every two hours, and thereby increasing the accuracy of the time-scale, originally devised by Mr. Beckley, in connexion with the self-recording meteorological instruments, has been adapted to the Kew, and also to the Mauritius and Bombay Self-recording Magnetographs, and the time-scale of the Kew Magnetographs has been made the same as those of the other instruments.

It was proposed in the last Report that the task of tabulating and reducing the magnetic curves produced at Kew subsequently to January 1865 should be performed by the staff at Kew working under the direction of Mr. Stewart. In accordance with this resolution 787 curves, being those of the declination from February 1865 to April 1867, have been measured for every hour, and the process of reduction of these measurements is well advanced.

The magnetical observations made at Ascension by Lieut. Rokeby, R.M., have been nearly reduced by Mr. Whipple, and it is proposed to communicate the results to the Royal Society.

A comparison of the Kew and Lisbon magnetic curves during the magnetic storm of February 20–25, 1866, made by Senhor Capello, of the Lisbon Observatory, has been communicated to the Royal Society, and will be found published in their Proceedings for May 28, 1868.

Mr. Stewart has likewise received from Senhor Capello a short paper, "On the reappearance of certain periods of Declination disturbance during two, three, or several days," which he proposes to communicate to the Royal Society.

The Rev. W. Sidgreaves and Mr. Stewart have been engaged in making intercomparisons of simultaneous disturbances of the declination at Stonyhurst and at Kew, for both of which stations the instruments have the same scale. It would appear from these that during slow disturbances there is an absolute identity between the indications of the two instruments, even to their most minute features. On the other hand, the more abrupt disturbances appear to be exaggerated at Stonyhurst as compared with Kew to an extent which appears (at first sight) to depend upon the abruptness. Messrs. Sidgreaves and Stewart are investigating this phenomenon, which has clearly

a physical and not an instrumental origin, and purpose communicating their results in a joint paper to the Royal Society.

3. *Meteorological Work.*—The meteorological work of the Observatory continues in the charge of Mr. Baker, who executes his duties very satisfactorily.

Since the Dundee Meeting, 78 Barometers have been verified, and 71 are at present in hand; 1139 Thermometers have likewise been verified, and 14 Standard Thermometers have been constructed for the Thermographs of the Meteorological Committee. 32 Thermograph Thermometers have likewise been tested, 24 of these being for the Meteorological Committee and 8 for opticians.

The self-recording meteorological instruments now at work at Kew will be again mentioned in the second division of this Report. These are in the charge of Mr. Baker, the Photography being superintended by Mr. Page.

Mr. Robert Addams has kindly made a preliminary experiment with his apparatus for freezing carbonic acid, which is now at Kew, and has also left specific instructions regarding it, so that the operation can in future be performed without assistance. The point corresponding to the temperature of freezing mercury has been determined for two Thermometers belonging to the Meteorological Committee.

The Self-recording Barographs, Thermographs, and Anemographs for the six outlying Observatories of the Meteorological Committee have been verified at Kew. A Self-recording Barograph and Thermograph have likewise been verified for Messrs. R. and J. Beck, opticians; and the verification of another set for Mr. Chambers, of the Colaba Observatory, has been very recently completed.

The experiments made on Aneroids at Kew, by the request and at the expense of the Meteorological Committee, have formed the subject of a communication recently made to the Royal Society by that body.

4. *Photoheliograph.*—The Kew Heliograph, in charge of Mr. De La Rue, continues to be worked in a satisfactory manner. During the past year 224 negatives have been taken on 140 days. 90 pictures of the Pagoda in Kew Gardens have likewise been taken, in the hope of being able by this means to determine accurately the angular diameter of the Sun.

Since the last Meeting of the Association, a series of solar researches, in continuation of the second series, has been published (the expense of printing having been defrayed by Mr. De La Rue), entitled "Researches on Solar Physics. Appendix to Second Series.—On the Distribution in Heliographic Latitudes of the Sun-spots observed by Carrington; by Messrs. De La Rue, Stewart, and Loewy."

Two papers have likewise been communicated to the Royal Society by these gentlemen. The first of these is entitled "Researches on Solar Physics. Heliographical Positions and Areas of Sun-spots observed with the Kew Photoheliograph during the years 1862 and 1863."

The second is entitled "Account of some Recent Observations on Sun-spots, made at the Kew Observatory."

Sun-spots continue likewise to be numbered after the manner of Hofrath Schwabe; and a Table, exhibiting the monthly groups observed at Dessau and at Kew for the year 1867, has been communicated to the Astronomical Society, and published in their Monthly Notices.

The measurements of the Kew pictures for the year 1864 are approaching completion; when complete, they will be communicated to the Royal Society. It is intended to work up rapidly the back years, preparatory to a final discussion.

Mr. De La Rue has recently received a letter from M. Struve, in which it is stated that the arrival at Kew of M. Berg, of the Wilna Observatory, in order to practise with the Photoheliograph, may be shortly expected.

5. *Apparatus for Verifying Sextants.*—Several determinations have been made of the angular distances between the collimators of this instrument; but the result appears to indicate a greater want of fixedness in these than is desirable. Should, however, the apparatus come to be extensively employed for the verification of sextants, this may be overcome by means of frequent determinations of these angular distances by a theodolite.

6. *Miscellaneous Work.*—The time and attention of the Observatory Staff have been so much absorbed during the last year with the regular work of the Observatory, that little or no progress has been made in miscellaneous experiments.

The instrument devised by Mr. Broun for the purpose of estimating the magnetic dip by means of soft iron, remains at present at the Observatory, awaiting Mr. Broun's return to England.

The Superintendent has received grants from the Royal Society for special experiments; and when these are completed, an account will be rendered to that Society.

(B) Work done at Kew as the Central Observatory of the Meteorological Committee.

This work may be divided into four heads, the first of these being the arrangement of self-recording meteorological instruments, their verification at Kew, and erection at the various stations; the second being the arrangement of a system of tabulating from the automatic records of these instruments; the third being the arrangement of a system by means of which the continued accuracy of the instruments themselves, and of their tabulated records, may be secured; while the fourth is the work done at Kew as being itself one of the Observatories of the Meteorological Committee.

1. *Arrangement, Verification, and Erection of Self-recording Instruments.*—In the last Report of this Committee a short account was given of the principles of construction of the system of self-recording meteorological instruments arranged at Kew, comprising the Thermograph, Barograph, and Anemograph. A more detailed account has since been given by the Meteorological Committee in their Report to Parliament for the year 1867, and it is therefore unnecessary to enter here into the subject. It ought, however, to be mentioned that the principle adopted in these instruments is to check the accuracy of their automatic records by means of reference to standards; and with this view the Kew Committee have constructed a Standard Wet and Dry Bulb Thermometer for each Thermograph, and has verified a Standard Barometer for each Barograph. When the various self-recording instruments had been completed by the opticians, they were sent to Kew, where they were examined and verified. They were then dispatched to their respective stations in charge of the observer, who had been previously instructed at Kew; and finally, Mr. Beckley, Mechanical Assistant at Kew, went to the various stations and superintended the erection of the instruments. By his aid this was accomplished in a very thorough and satisfactory manner.

2. *System of Tabulation.*—It is not proposed to discuss here the system of tabulation. This has already been done, to a certain extent, in the Report of the Meteorological Committee presented to Parliament; and the whole subject will, it is hoped, be fully treated of on some future occasion. Suffice

Accounts of the Kew Committee of the British Association from September 4, 1867, *to August* 19, 1868.

RECEIPTS.

			£	s.	d.
Balance from last account			10	2	4
Received from the General Treasurer			600	0	0
,, for the verification of Meteorological Instruments from the Meteorological Office	38 10 0				
,, ,, from Opticians	44 0 0				
			82	10	0
,, from the India Office for the verification of Portable Magnetometers			15	0	0
,, from the Meteorological Committee for the verification at Kew, and erection at their various Stations, of six sets of Self-recording Meteorological Instruments, including instructions given to observers			180	0	0
,, from the Meteorological Committee for the construction of Standard Thermometers			28	0	0
Balance			0	0	5
			£915	12	9

PAYMENTS.

		£	s.	d.
Salaries, &c.:—				
To B. Stewart, four quarters, ending 1st October, 1868	200 0 0			
Ditto, allowed for petty travelling expenses	10 0 0			
G. Whipple, four quarters, ending 18th September, 1868	100 0 0			
T. Baker, four quarters, ending 29th September, 1868	75 0 0			
F. Page, four quarters, ending 2nd October, 1868	50 0 0			
R. Beckley, 50 weeks, ending 17th August, 1868, at 40*s*. per week	100 0 0			
		535	0	0
Apparatus, Materials, Tools, &c.		75	10	0
Ironmonger, Carpenter, Mason		50	9	2
Printing, Stationery, Books, Postage		42	7	7
Coals and Gas		43	19	1
House Expenses, Chandlery, &c.		23	17	1
Porterage and petty expenses		18	1	10
Expenses connected with the verification and erection of Meteorological Self-recording Instruments		114	8	0
Rent of Land attached to the Observatory and Pillars up to 10th October, 1868		12	0	0
		£915	12	9

Examined with the vouchers and found correct.

6th August, 1868.

W. SPOTTISWOODE.

it to say, that the system of tabulation was arranged at Kew, and that the tabulating instruments were all verified there before being sent to their respective observatories.

3. *Verification of Records.*—It has already been mentioned that the competency of the observers at the various stations to undertake the charge of the self-recording instruments was secured by a course of instruction at Kew, where they became acquainted with the principles of construction of the various instruments, with the photographic process necessary to obtain curves, and with the system of tabulation. In addition to this, the instruments were erected at the various stations by Mr. Beckley, and each observer was thus well started. It is not, however, enough, in a project of this nature, to secure a good beginning; it is, moreover, indispensable to see that the standard of excellence is maintained.

For this purpose it is proposed by the Meteorological Committee that Mr. Stewart should personally visit all the Observatories every year; in addition to which, some one of the Kew assistants might occasionally visit some station, with a specific object in view. Mr. Stewart has already visited Stonyhurst, Glasgow, and Aberdeen; and, in addition to the preliminary visit to the various stations made by Mr. Beckley, Mr. Whipple has visited Falmouth.

Besides this inspection, it is also necessary to check at Kew the accuracy of the tabulated results that arrive there from the various stations. A close and constant scrutiny of these results is therefore made at Kew; and when any error is detected, it is brought before the notice of the observer who made it. All this involves a very considerable amount of labour, more especially at the commencement of the undertaking, and until the various observatories are in thorough working order. For the purpose of securing accuracy and uniformity in the reduction of the records of these instruments, it has been proposed that a set of rules should be drawn up under the sanction of this Committee.

4. *Work done at Kew as one of the Observatories of the Meteorological Committee.*—This consists in keeping the Barograph, Thermograph, and Anemograph furnished by the Meteorological Committee in constant operation. The Barograph is erected in the room which contains the Magnetographs, and which has a very small daily range of temperature. The outer part of the Thermograph is attached to the north side of the Observatory, towards the west, while the Anemograph has been erected above the centre of the dome, so as not to interfere with the Photoheliograph.

For the first two of these instruments traces in duplicate are obtained, one set being sent to the Meteorological Office, and one retained at Kew; as regards the Anemograph, the original records are sent, while a copy of these on tracing-paper is retained.

The tabulations from the curves of the Kew instruments, and the examination of the results forwarded to Kew from the outlying Observatories, so far as this last is not personally done by Mr. Stewart, are performed in a very satisfactory manner by Messrs. Whipple, Baker, and Page.

Mr. Steventon, a nephew of Captain Toynbee, of the Meteorological Office, has been in attendance at the Observatory for instruction for about twelve months, and latterly has given much assistance in the meteorological department of the Observatory, with the details of which he is now fully conversant.

J. P. GASSIOT, *Chairman.*

Kew Observatory, 7th August, 1868.

Recommendations adopted by the General Committee at the Norwich Meeting in August 1868.

[When Committees are appointed, the Member first named is regarded as the Secretary, except there is a specific nomination.]

Involving Grants of Money.

That the sum of £600 be placed at the disposal of the Council for maintaining the Establishment of the Kew Observatory.

That Professor Tait, Professor Tyndall, and Dr. Balfour Stewart be a Committee for the purpose of repeating Principal J. D. Forbes's experiments on the Thermal Conductivity of Iron, and extending them to other metals; and that the sum of £50 be placed at their disposal for the purpose.

That Dr. Joule, Sir W. Thomson, Professor Tait, Dr. Balfour Stewart, and Professor G. C. Foster be reappointed as a Committee for the purpose of executing a remeasurement of the Dynamical Equivalent of Heat; that Professor Foster be the Secretary, and that the sum of £50 be placed at their disposal for the purpose.

That the Committee for the purpose of investigating the rate of increase of Underground Temperature downwards in various localities of dry land and under water, consisting of Sir William Thomson, Dr. Everett, Sir Charles Lyell, Bart., Principal Forbes, Mr. J. Clerk Maxwell, Professor Phillips, Mr. G. J. Symons, Mr. Balfour Stewart, Professor Ramsay, Mr. Geikie, Mr. Glaisher, Rev. Dr. Graham, Mr. E. W. Binney, Mr. George Maw, and Mr. Pengelly, be reappointed; that Dr. J. D. Everett be the Secretary, and that the sum of £30 be placed at their disposal for the purpose.

That the Committee for reporting on the Rainfall of the British Isles, consisting of Mr. Charles Brooke, Mr. Glaisher, Professor Phillips, Mr. G. J. Symons, Mr. J. F. Bateman, Mr. R. W. Mylne, Mr. T. Hawksley, Professor Adams, Mr. C. Tomlinson, and Professor Sylvester, be reappointed; that Mr. G. J. Symons be the Secretary, and that the sum of £50 be placed at their disposal.

That the Committee on Tidal Observations be reappointed, and consist of Sir W. Thomson, Professor Adams, Professor J. W. M. Rankine, Mr. J. Oldham, and Captain Richards (with power to add to their number); and that the sum of £100 be placed at their disposal.

That the Lunar Committee be reappointed, and consist of Mr. J. Glaisher, Lord Rosse, Sir J. Herschel, Bart., Professor Phillips, Rev. C. Pritchard, Mr. W. Huggins, Mr. W. R. Grove, Mr. W. De La Rue, Mr. C. Brooke, Rev. T. W. Webb, Herr Schmidt, Admiral Manners, Mr. W. R. Birt, and Lieut.-Colonel Strange; and that the sum of £50 be placed at their disposal.

That Dr. Anderson and Mr. Catton be a Committee for the purpose of continuing the researches of Mr. Catton on the Synthesis of Organic Acids; and that the sum of £12 be placed at their disposal for the purpose.

That Dr. Frankland and Mr. McLeod be a Committee for the purpose of investigating the composition of the gases dissolved in deep-well water; and that the sum of £25 be placed at their disposal for the purpose.

That Dr. Matthiessen, Mr. Abel, and Mr. David Forbes be a Committee for the purpose of investigating the Chemical Nature of Cast Iron; and that the sum of £80 be placed at their disposal for the purpose.

That Sir Charles Lyell, Bart., Professor Phillips, Sir John Lubbock, Bart., Mr. John Evans, Mr. Edward Vivian, Mr. William Pengelly, Mr. George Busk, and Mr. W. Boyd Dawkins be a Committee for the purpose of continuing the

exploration of Kent's Cavern, Torquay; that Mr. Pengelly be the Secretary, and that the sum of £150 be placed at their disposal for the purpose.

That the Committee for the purpose of investigating the Leaf-beds of the Lower Bagshot Series of the Hampshire Basin, consisting of Mr. W. S. Mitchell, Mr. Robert Etheridge, Professor J. Morris, and Mr. G. Maw, be requested to continue their investigations; that Mr. Mitchell be the Secretary, and that the sum of £30 be placed at their disposal for the purpose.

That Dr. P. M. Duncan and Mr. Henry Woodward be requested to continue their Researches on British Fossil Corals; and that the sum of £50 be placed at their disposal for the purpose.

That the Committee for the purpose of investigating the veins containing Organic Remains which occur in the Mountain Limestone of the Mendips and elsewhere, consisting of Mr. C. Moore, the Rev. L. Jenyns, and the Rev. H. H. Winwood, be requested to continue their investigations; that Mr. Moore be the Secretary, and that the sum of £10 be placed at their disposal for the purpose.

That Dr. Bryce, Sir W. Thomson, Mr. D. Milne-Home, and Mr. Macfarlane be requested to continue the researches on Earthquakes in Scotland; that Dr. Bryce be the Secretary, and that the sum of £14 be placed at their disposal for the purpose.

That Mr. Henry Woodward, Dr. Duncan, Professor Harkness, and Mr. James Thomson be a Committee for the purpose of making and photographing sections of such Mountain Limestone Fossils as require to be cut in order to display their structure; that Mr. Woodward be the Secretary, and that the sum of £25 be placed at their disposal for the purpose.

That Professor Beete Jukes, Professor Huxley, and Mr. W. H. Baily be a Committee for the purpose of exploring the fossils of the two Kiltorcan quarries, co. Kilkenny; that Mr. W. H. Baily be the Reporter, and that the sum of £20 be placed at their disposal for the purpose.

That Mr. W. Carruthers, Mr. Busk, and Professor Balfour be a Committee for the purpose of continuing researches into the Fossil Flora of Britain; that Mr. Carruthers be the Secretary, and that the sum of £25 be placed at their disposal for the purpose.

That Dr. B. W. Richardson, Professor Humphry, and Dr. Sharpey be a Committee for the purpose of continuing researches on the physiological action of the Methyl Series and allied organic compounds; and that the sum of £30 be placed at their disposal for the purpose.

That Dr. M. Foster, Mr. W. H. Flower, and Professor Humphry be a Committee for the purpose of investigating the course taken by the products of digestion; that Dr. M. Foster be the Secretary, and that the sum of £10 be placed at their disposal for the purpose.

That Dr. Crum Brown, Professor Balfour, and Dr. Frazer be a Committee for the purpose of investigating the relation between Chemical Constitution and Physiological Action; that Dr. Crum Brown be the Secretary, and that the sum of £15 be placed at their disposal for the purpose.

That Mr. E. Ray Lankester, Mr. Charles Stewart, and Dr. Arthur Gamgee be reappointed as a Committee for the purpose of investigating Animal Substances with the Spectroscope; that Mr. E. Ray Lankester be the Secretary, and that the sum of £5 be placed at their disposal for the purpose.

That Dr. E. Perceval Wright, Dr. J. E. Gray, and the Rev. Dr. Tristram be a Committee for the purpose of dredging on the coast of Lisbon; that Dr. E. P. Wright be the Secretary, and that the sum of £20 be placed at their disposal for the purpose.

That Sir John Lubbock, Bart., Mr. H. T. Stainton, and the Rev. H. B. Tristram be a Committee for the purpose of preparing a record of Zoological Literature for the year 1868; that Sir John Lubbock be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That the Metric Committee be reappointed, such Committee to consist of Sir John Bowring, The Right Hon. C. B. Adderley, M.P., Mr. Samuel Brown, Mr. W. Ewart, M.P., Dr. Farr, Mr. Frank P. Fellows, Professor Frankland, Professor Hennessy, Mr. James Heywood, Sir Robert Kane, Professor Leone Levi, Professor W. A. Miller, Professor Rankine, Mr. C. W. Siemens, Colonel Sykes, M.P., Professor A. W. Williamson, Mr. James Yates, Dr. George Glover, Mr. Joseph Whitworth, Mr. J. R. Napier, Mr. H. Dircks, Mr. J. V. N. Bazalgette, Mr. W. Smith, Mr. W. Fairbairn, and Mr. John Robinson; that Professor Leone Levi be the Secretary, and that the sum of £25 be placed at their disposal.

That the Committee, consisting of Mr. J. Scott Russell, Mr. T. Hawksley, Mr. J. R. Napier, Mr. William Fairbairn, and Professor W. J. M. Rankine, to analyze and condense the information contained in the Reports of the "Steam-ship Performance" Committee and other sources of information on the same subject, with power to employ paid calculators or assistants, if necessary, be reappointed; and that the sum of £30 be placed at their disposal for the purpose.

That the Committee, consisting of Mr. W. Fairbairn and Mr. Tait, for continuing experiments with a view to test the improvements in the manufacture of Iron and Steel, be reappointed; and that the grant of £100 placed at their disposal last year and not drawn be renewed.

That a Committee, consisting of Mr. R. B. Grantham, Mr. W. B. Harding, Dr. J. H. Gilbert, and Dr. Angus Smith (with power to add to their number), be appointed to report on the treatment and utilization of Sewage; and that the sum of £10 be placed at their disposal for the purpose.

Applications for Reports and Researches not involving Grants of Money.

That Lieut.-Col. Strange, Professor Sir W. Thomson, Professor Tyndall, Professor Frankland, Dr. Stenhouse, Dr. Mann, Mr. Huggins, Mr. Glaisher, Professor Williamson, Professor Stokes, Professor Fleeming Jenkin, Professor Hirst, Professor Huxley, and Dr. Balfour Stewart be a Committee for the purpose of inquiring into, and of reporting to the British Association the opinion at which they may arrive concerning the following questions:—

I. Does there exist in the United Kingdom of Great Britain and Ireland sufficient provision for the vigorous prosecution of Physical Research?

II. If not, what further provision is needed? and what measures should be taken to secure it?

and that Dr. Robert James Mann be the Secretary.

That Mr. E. J. Lowe, Professor Frankland, Professor A. W. Williamson, Mr. Glaisher, Dr. Moffat, Mr. C. Brooke, Dr. Andrews, and Dr. B. Ward Richardson be a Committee for the purpose of promoting accurate Meteorological Observations of Ozone; and that Mr. Lowe be the Secretary.

That the Committee on Electrical Standards, consisting of Professor Williamson, Professor Sir Charles Wheatstone, Professor Sir W. Thomson, Professor W. A. Miller, Dr. A. Matthiessen, Mr. Fleeming Jenkin, Sir Charles Bright, Mr. J. Clerk Maxwell, Mr. C. W. Siemens, Mr. Balfour

Stewart, Dr. Joule, Mr. C. F. Varley, Mr. G. C. Foster, and Mr. C. Hockin, be reappointed; and that Professor Fleeming Jenkin be the Secretary.

That the Committee on Luminous Meteors and Aërolites, consisting of Mr. Glaisher, Mr. R. P. Greg, Mr. E. W. Brayley, Mr. Alexander Herschel, and Mr. C. Brooke, be reappointed; and that Mr. Herschel be the Secretary.

That the Committee, consisting of Dr. Tyndall, Dr. Lyon Playfair, Dr. Odling, Rev. C. Pritchard, Professor Kelland, Professor W. A. Miller, Professor Foster, Professor Williamson, Mr. Griffith, Mr. J. M. Wilson, and James Young, be reappointed for the purpose of inquiring into the present methods of teaching the elements of Dynamics, Experimental Physics, and Chemistry in schools of various classes, and of suggesting the best means of promoting this object in accordance with the Recommendations of the Report of the Committee appointed by the Council; and that Professor Foster and Dr. Odling be the Secretaries.

That Mr. W. H. L. Russell be requested to prepare a Report on recent progress in the theory of Elliptic and Hyperelliptic Transcendents.

That Mr. Fairley be requested to continue his researches on the Polyatomic Cyanides.

That Mr. H. Bauerman, Professor Otto Torell, and Professor Ramsay be a Committee for the purpose of preparing a Report on Ice as an Agent of Geologic Change; and that Mr. H. Bauerman be the Secretary.

That Mr. F. Buckland, Rev. H. B. Tristram, Mr. H. E. Dresser, and Mr. Tegetmeier be a Committee for the purpose of collecting evidence as to the practicability of establishing "*a close time*" for the protection of indigenous animals; and that Mr. F. Buckland be the Secretary.

That the Committee to prepare a Report on Agricultural Machinery be reappointed, such Committee to consist of the Duke of Buccleuch, the Rev. Patrick Bell, Mr. David Greig, Mr. J. Oldham, Mr. William Smith, C.E., Mr. Harold Littledale, The Earl of Caithness, Mr. Robert Neilson, Professor Rankine, Mr. F. J. Bramwell, Professor Willis, and Mr. Charles Manby; and that Messrs. P. Le Neve Foster and J. P. Smith be the Secretaries.

That Mr. Thomas Hawksley, C.E., Professor Rankine, Mr. Richard B. Grantham, C.E., Sir A. S. Waugh, and Mr. T. Login, C.E. (with power to add to their number) be a Committee for the purpose of reporting on the Laws of the Flow and Action of Water containing solid Matter in Suspension.

That a Committee, consisting of Mr. W. Fairbairn, Mr. Joseph Whitworth, Mr. Lavington, Mr. Fletcher, Mr. F. J. Bramwell (with power to add to their number), be appointed to consider and report how far Coroner's Inquisitions are satisfactory tribunals for the investigation of Boiler Explosions, and to consider the manner in which these tribunals may be improved.

That the Committee, consisting of Admiral Sir Edward Belcher, Mr. J. Oldham, Mr. J. R. Napier, Mr. George Fawcus, Mr. William Smith, and Mr. J. Sissons, be reappointed to Report on the Regulations affecting the safety of Merchant Ships and their Passengers.

That a Committee, consisting of Mr. C. W. Merrifield, F.R.S., Mr. G. P. Bidder, Captain Douglas Galton, F.R.S., Mr. F. Galton, F.R.S., Professor Rankine, F.R.S., and Mr. W. Froude, be appointed to report on the state of existing knowledge on the stability, propulsion, and sea-going qualities of Ships, and as to the application which it may be desirable to make to Her Majesty's Government on these subjects.

Involving Application to Government.

That General Sir Andrew Waugh, Sir Arthur Phayre, General G. Balfour, General Sir Vincent Eyre, Captain Sherard Osborn, Mr. George Campbell, and Dr. Thomas Thomson be a Committee for the purpose of representing to the Secretary of State for India the desirability of an exploration being made of the district between the Burhampooter, the Upper Irrawaddy, and the Yang-tsze-Kiang, with a view to a route being established between the navigable parts of those rivers; and that Dr. T. Thomson be the Secretary.

That application be made to the Admiralty for aid in establishing stations in the Orkneys and on the Coast of Ireland, where the actual temperature of the sea may be taken either daily or weekly, so as to prove or disprove any alteration of temperature presumed to result from the deflection of the Gulf-of-Florida Stream; that Admiral Manners, Admiral Sir E. Belcher, Admiral Ommanney, and Mr. Milne-Home be a Committee to press this matter on the Government.

Communications to be published in extenso *in the Annual Report.*

That the communication of Mr. Huggins on the Progress of Spectroscopic Discovery be printed *in extenso* among the Reports, and that he be requested to prepare an abstract of the Discourse which he delivered to the British Association at its Meeting at Nottingham, and prefix it to the paper referred to.

That Father Secchi's communication, entitled "Researches in the Spectral Analysis of the Stars," be printed *in extenso* among the Reports.

That Baron Mädler's paper, "on Changes of the Moon's Surface," be printed *in extenso* among the Reports.

That the Paper by C. W. Siemens, "On Puddling Iron," be printed in the Reports *in extenso.*

That the word "Ethnology" be omitted from the designation of Section E.

That henceforth the Parliamentary Committee consist of those Members of the Council who are likewise Members of one of the two Houses of Parliament.

That Members and Committees who may be entrusted with sums of money for collecting specimens of Natural History be requested to reserve the specimens so obtained for distribution by authority of the Association.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Norwich Meeting in August 1868. The names of the Members who would be entitled to call on the General Treasurer for the respective Grants are prefixed.

	£	s.	d.
Kew Observatory.			
Maintaining the Establishment of Kew Observatory	600	0	0
Mathematics and Physics.			
Tait, Professor.—Thermal Conductivity of Iron and other Metals	30	0	0
*Joule, Dr.—Remeasurement of the Dynamical Equivalent of Heat (renewed)	50	0	0
*Thomson, Professor Sir W.—Underground Temperature	30	0	0
*Thomson, Professor Sir W.—Tidal Observations	100	0	0
*Brooke, Mr.—British Rainfall	50	0	0
*Glaisher, Mr.—Lunar Committee	50	0	0
Chemistry.			
*Anderson, Dr.—Synthesis of Organic Acids (renewed)	12	0	0
Frankland, Dr.—Composition of Gases dissolved in Deep-Well Water	25	0	0
Matthiessen, Dr.—Chemical Nature of Cast Iron	80	0	0
Geology.			
*Lyell, Sir C., Bart.—Kent's-Cavern Exploration	150	0	0
*Mitchell, Mr. W. S.—Leaf-beds of the Lower Bagshot series..	30	0	0
*Duncan, Dr. P. M.—British Fossil Corals	50	0	0
*Moore, Mr. C.—Veins containing Organic Remains in the Mountain Limestone of the Mendips and elsewhere......	10	0	0
*Bryce, Dr.—Earthquakes in Scotland (renewed)	14	0	0
Woodward, Mr. H.—Sections of Mountain-Limestone Fossils	25	0	0
Biology.			
Jukes, Professor.—Kiltorcan Fossils, Kilkenny............	20	0	0
*Carruthers, Mr.—Fossil Flora of Britain	25	0	0
*Richardson, Dr.—Physiological Action of the Methyl Series..	30	0	0
Foster, Dr.—Products of Digestion......................	10	0	0
Brown, Dr. Crum.—Relation between Chemical Constitution and Physiological Action	15	0	0
*Lankester, Mr. E. Ray.—Investigation of Animal Substances with the Spectroscope (renewed)	5	0	0
Wright, Dr. E. P.—Dredging on the coast of Lisbon	20	0	0
*Lubbock, Sir J., Bart.—Record of the Progress of Zoology..	100	0	0
Statistics and Economic Science.			
*Bowring, Sir J.—Metrical Committee....................	25	0	0
Mechanics.			
*Russell, Mr. J. Scott.—Analysis of Reports on Steam-ship Performance	30	0	0
*Fairbairn, Mr. W.—Manufacture of Iron and Steel (renewed)	100	0	0
Grantham, Mr.—Treatment and utilization of Sewage	10	0	0
Total......	£1696	0	0

* Reappointed.

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain-Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£434	14	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	89	5	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£918	14	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Subterranean Temperature	8	6	0
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
Thermometers	16	4	0
	£956	12	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast-Iron Experiments	100	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	331	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	6	16	6
Animal Secretions	10	10	0
Steam-engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0

	£	s.	d.
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	0
Railway Sections	38	1	6
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Obervations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Cooperation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Cooperation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3

	£	s.	d.
Influence of Light on Plants......	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata ...	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas.....1842	100	0	0
Geographical Distributions of Marine Zoology............1842	10	0	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	3
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument 1842	10	3	6
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh........................	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells...	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds...............1843	2	0	7
Vitality of Seeds...............1844	7	0	0
Marine Zoology of Cornwall......	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks 1843	15	14	8
	£830	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1839...............	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials...............	60	0	0
Researches in Asphyxia...........	6	16	2
Examination of Fossil Shells......	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall......	10	0	0
Marine Zoology of Britain	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	3
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1839	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall ...	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogues of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants...............	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants...............	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves ...	50	0	0

	£	s.	d.
Periodical Phenomena	15	0	0
Meteorological Instrument, Azores	25	0	0
	£345	18	0

1851.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including Mbalance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.

	£	s.	d.
Maintaining the Establishment at Kew Obssrvatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

1856.

	£	s.	d.
Maintaining the Establishment at Kew Observatory:— 1854......£ 75 0 0; 1855......£500 0 0	575	0	0
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	9
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9

1857.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-Boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seeds	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£1241	7	0

1861.	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860 ...... £50 0 0; 1861 ...... £22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahago	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	1
Constituents of Manures	25	0	0
	£1111	5	10

1862.	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland	25	0	0
Connexion of Storms	20	0	0
Dredging North-East Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-Electric Currents	5	0	0
	£1293	16	6

1863.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
—— Construction and distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-Electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroids	10	0	0
	£1608	3	10

1864.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging Shetland	75	0	0
Dredging Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-Gauges	19	15	8
Cast-Iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-Gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	0
Luminous Meteors	40	0	0
	£1591	7	10

1866.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-Bed	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	20	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches	30	0	0
Palestine Exploration Fund	100	0	0
	£1750	13	4

1867.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-Bed	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c. Leaf-Beds	30	0	0
Dredging, Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyle and Methyle series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record	100	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	100	0	0
British Rainfall	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl series	25	0	0
Mercury and Bile	25	0	0
Organic remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Spectroscopic investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

Extracts from Resolutions of the General Committee.

Committees and individuals, to whom grants of money for scientific purposes have been entrusted, are required to present to each following Meeting of the Association a Report of the progress which has been made; with a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of pecuniary aid for scientific purposes from the funds of the Association expire at the ensuing Meeting, unless it shall appear by a Report that the Recommendations have been acted on, or a continuation of them be ordered by the General Committee.

Members and Committees who are entrusted with sums of money for collecting specimens of Natural History are requested to reserve the specimens so obtained for distribution by authority of the Association.

In each Committee, the Member first named is the person entitled to call on the Treasurer, William Spottiswoode, Esq., 50 Grosvenor Place, London, S.W., for such portion of the sum granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named shall be deemed to include, as a part of the amount, the specified balance which may remain unpaid on the former grant for the same object.

General Meetings.

On Wednesday Evening, August 19, at 8 P.M., in the Drill Hall, His Grace the Duke of Buccleuch, K.G., F.R.S., President, resigned the office of President to Dr. Joseph Dalton Hooker, F.R.S., F.L.S., who took the Chair, and delivered an Address, for which see page lviii.

On Thursday Evening, August 20, at 8 P.M., a Soirée took place in St. Andrew's Hall.

On Wednesday Evening, August 26, in the Drill Hall, Prof. Huxley, LL.D., F.R.S., delivered a Discourse on "Chalk," to the Operative Classes of Norwich.

On Friday Evening, August 21, at 8.30 P.M., in the Drill Hall, J. Fergusson, Esq., F.R.S., delivered a Discourse on the "Archæology of the Early Buddish Monuments."

On Tuesday Evening, August 25, at 8 P.M., in the Drill Hall, Dr. W. Odling, F.R.S., delivered a Discourse on "Reverse Chemical Actions;" after which, at 9 P.M., a Soirée took place in St. Andrew's Hall.

On Wednesday, August 26, at 3 P.M., the concluding General Meeting took place, when the Proceedings of the General Committee, and the Grants of Money for Scientific purposes, were explained to the Members.

The Meeting was then adjourned to Exeter*.

* The Meeting is appointed to take place on Wednesday, August 18, 1869.

ADDRESS

OF

JOSEPH D. HOOKER, F.R.S.,

D.C.L. OXON.; LL.D. CANTAB.; &c.

PRESIDENT.

My Lords, Ladies, and Gentlemen,

Thirty years will to-morrow have elapsed since I first attended a Meeting of the British Association; it was the one which opened at Newcastle on the 20th of August, 1838. On that occasion, the Council of the Association resolved to recommend to Her Majesty's Government the despatch of an expedition to the Antarctic regions, under the command of Captain James Ross; and it was from Newcastle that I wrote to my friends announcing my resolve to accompany it, in whatever capacity I could obtain a situation amongst its officers. It was thus that my scientific career was first shaped; and it is to this expedition, which was one of the very earliest results of the labours of the British Association, that I am indebted for the honour you have conferred upon me, in placing me in your President's chair.

If I now look back with pride to those immediately following years, when I had a share, however small, in the discovery of the Antarctic Continent, the Southern Magnetic Pole, the Polar Barrier, and the Ice-clad Volcanos of Victoria Land, I do so also with other and far different feelings. Thirty years, as statisticians tell us, represent the average duration of human life; I need not say, that, as measured by the records of the British Association, a human lifetime is far shorter than this; for of the fourteen officers who presided over us in 1838, but two remain, your former President and devoted adherent for thirty-five years, Sir Roderick Murchison, who delivered the opening address on that occasion, and whose health, I regret to add, prevents his attendance at this Meeting; and your faithful and evergreen Secretary, Professor Phillips, upon whose presence here I congratulate both you and him.

Again, looking back beyond thirty years ago in the pages of your Records, I find those to have been halcyon years for Presidents, when the preparation and delivery of the Addresses devolved upon the Treasurer, Secretary, or other officer than the President; and that in fact Presidential Addresses date from the first Meeting after that at Newcastle. Of late years these Addresses have been regarded, if not as the whole duty of the President, certainly as his highest; for your sakes, as well as for my own, I wish this were not so; both because there are amongst your officers so many men far more competent than I am, and because I believe that the responsibility which the preparation of these Addresses entails, disadvantageously limits your choice of Presidents. The impression is very prevalent that the Address should either be a scientific *tour de force*, philosophical and popular, or a *résumé* of the progress of one or more important branches of science; and this view of the duty has greatly embarrassed me, inasmuch as I am unable

to fulfil either of these requirements. On various occasions during the last half year I have essayed to fulfil the wishes of my botanical friends, that I should either discuss the phenomena of the Vegetable kingdom in their relation to collateral sciences, or sketch the rise and progress of Scientific Botany during the present century, or a portion of it; but every such essay has been quickly frustrated by the pressure of official duties. Such themes require much research, much thought, and, above all, some continuous leisure, during which the whole mind may be concentrated on the method of treatment, as well as on the material to be treated of; and this leisure was incompatible with the discharge of my duties as administrator of a large public department, entailing a ceaseless correspondence with the Government offices, and with Botanical establishments all over the globe. And I do not ask your indulgence for myself alone, for there are at this Meeting official men of scientific attainments, who have accepted the Presidentships of Sections, but who, on leaving their posts to do your bidding, drag a lengthening chain of correspondence after them, and sacrifice no short portion of those brief holidays which are allowed to public officers. After all, it is deeds, not words, that we want from them; and I am proud to find our Sections presided over by men who have won their spurs in their respective sciences, and who will wear them in the chairs they occupy, and use them, too, if needs must.

For my own part I propose to offer you some remarks upon several matters to which the attention of your Committee was directed when at Dundee, and then upon some of the great advances that have been made in Botany during the last few years; this will infallibly drag me into Darwinism: after which I shall allude to some matters connected with that dawning science, the Early History of Mankind, a theme which will be a distinguishing collateral feature of the Norwich Association. If in all this I disappoint you, it will be my solace to hope that I may thereby break the fall of some future President, who, like myself, may have the will, but not the time, adequately to meet your great expectations.

Before commencing, however, I must advert to a circumstance which cannot but be uppermost in the minds of all habitual attendants at these annual gatherings; it is, that but for a severe accident there would have been present here to-night the oldest surviving, and indeed the first but two of the Presidents of the British Association: my geological friends will understand to whom I allude, as that Rock of Science in whom age and the heat and shocks of Scientific Controversy have wrought no metamorphosis, and developed no cleavage planes—a man of whom both Norwich and the Association are proud—your Canon, our father, Sedgwick.

My first duty as President is the pleasant one of introducing to you the members of the International Congress of Pre-historic Archæology, who, under the Presidency of Sir John Lubbock, himself a master of this branch of knowledge, open their third session to-morrow in this city. The researches which specially occupy the attention of the Congress are perhaps the most fascinating that ever engaged the faculties of man; and pursued as they now are in a scientific spirit, and in due subjection to scientific methods, they will command all the sympathy, and their meetings will receive all the support that my fellow members of the British Association can afford to them. And there is one way in particular by which we can show our goodwill and give our support, so simple that I hope no one will neglect it; and that is that we shall all call at their official residence at the Free Library, inscribe our names in their books, and obtain cards for their meetings.

The next subject which I have to bring officially before you will interest the members of the Congress no less than ourselves, and relates to the action of your Committee appointed last year to represent to the Secretary of State for India "the great and urgent importance of adopting active measures to obtain reports on the physical form, manners, and customs of the indigenous populations of India, and especially of those tribes which are still in the habit of erecting Megalithic monuments."

Upon consideration the Committee decided that it would be better in the first instance, to direct the attention of the Secretary of State to the last-mentioned subject only, both because the whole inquiry was so vast, and because systematic efforts are now being made by the Indian Government to obtain photographs and histories of the native Indian tribes. Their efforts are, as regards the photographs obtained in India, eminently successful, which renders it all the more disappointing that the descriptive matter appended to them in this country, and which is happily anonymous, is most discreditable to the authority under which it is issued*.

It will, no doubt, surprise many here to be told that there exists within 300 miles of the British capital of India, a tribe of semi-savages who habitually erect dolmens, menhirs, cysts, and cromlechs, almost as gigantic in their proportions as the so-called Druidical remains of Western Europe, which they greatly resemble in appearance and construction; and what is still more curious, though described and figured nearly a quarter of a century ago by Col. Yule, the eminent oriental geographer, except by Sir John Lubbock these erections are scarcely alluded to in the modern literature of prehistoric monuments. In the Bengal Asiatic Journal for 1844, you will find Col. Yule's description of the Khasia people of East Bengal; an Indo-Chinese race, who keep cattle but drink no milk, estimate distances traversed by the mouthfuls of pawn chewed *en route*, and amongst whom the marriage tie is so loose that the son commonly forgets his father, while the sister's son inherits property and rank. Dr. Thomson and I dwelt for some months amongst the Khasia people, now eighteen years ago, and found Col. Yule's account to be correct in all particulars. The undulatory eminences of the country, some 4–6000 feet above the level of the sea, are dotted with groups of huge unpolished square pillars, and tabular slabs supported on three or four rude piers.

In one spot, buried in a sacred grove, we found a nearly complete circle of menhirs, the tallest of which was thirty feet out of the ground, six feet broad, and two feet eight inches thick; and in front of each was a dolmen or cromlech of proportionately gigantic pieces of rock.

The largest slab hitherto measured is thirty-two feet high, fifteen feet broad, and two feet thick. Several that we saw had been very recently erected, and we were informed that every year some are put up, but not during the rainy season, which we spent in the country. The method of separating the blocks is by cutting grooves, along which fires are lighted, and into which, when heated, cold water is run, which causes the rock to split along the groove; the lever and rope are the only mechanical aids used in transporting and erecting the blocks. The objects of their erection are various—sepulture, marking spots where public events had occurred, &c. It is a curious fact that the Khasian word for a stone, "Mau," as commonly occurs in the names of their villages and places, as that of Man, Maen, and Men, does in those of

* I am informed that measures have been taken to repair this, and that Col. Meadows Taylor, than whom a more competent man could not be found, has been appointed to undertake the literary and scientific portions in future.

Brittany, Wales, Cornwall, &c.; thus Mausmai signifies in Khasia the Stone of Oath; Mamloo, the Stone of Salt; Mauflong, the Grassy Stone, just as in Wales, Penmaenmawr signifies the Hill of the Big Stone; and in Brittany a Menhir is a Standing Stone, and a Dolmen a Table Stone, &c.

At the date of Col. Yule's, as of my visit to these people, our intercourse with them was limited, and not always friendly; we were ignorant of their language, and they themselves were far from communicative. Of late, however, the country has been more opened up, and the establishment of a British cantonment amongst them renders it all the more important that the inquiry into their origin, language, beliefs, customs, &c. should be followed up without delay. This will now be done, thanks to your representations; and I cannot doubt that it will throw great light upon that obscure and important branch of Prehistoric Archæology, the Megalithic monuments of Western Europe.

The Council of the Association, upon the recommendation of the Biological Section, appointed a committee to report upon the subject of the Government of the Natural-History Collections of the British Museum; which resulted in a deputation which represented to the Prime Minister in the name of the Council, that it was desirable that these collections should be placed under the control of a single officer, who should be directly responsible to a Minister of the Crown; and that this opinion was shared by an overwhelming majority of British naturalists. The reasons stated were, that there appeared no reason why the National Collections of Natural History should be administered in a way different from that which was found applicable to the Royal Gardens and Botanical Collections at Kew, the Museum of Practical Geology, and the Royal Observatory at Greenwich*, and that the interposition of any Board or Committee between the Superintendent of the Collections and the Government must interfere with the responsibility of the Superintendent and the efficient control of the Minister.

It was not the first time that this subject had been brought before Her Majesty's Government: since ten years previously a few Naturalists, consisting of Messrs. Bentham, Busk, Darwin, Huxley, Dr. Carpenter, and myself, together with the late Professors Lindley, Henslow, Harvey, and Henfrey, had presented a memorial to Mr. Disraeli, then Chancellor of the Exchequer, embodying precisely the same views as to the government of the Natural-History Department of the British Museum, together with a scheme for the administration of the whole Metropolitan Natural-History Collections, Geological and Botanical; and I have only to add, regarding this document, that the surviving memorialists have not during the ten intervening years, found reason to alter the views therein expressed on any vital point.

Of the objections to the present system of government by Trustees, some of the most grave have been stated by Mr. Andrew Murray in a communication†

* Since writing the above, I have been reminded of the constitution of the Board of Visitors to the Royal Observatory by the Astronomer Royal, who has favoured me with copies of the Regulations of the Royal Observatory (1852), and of his Report (for 1868) to the Board of Visitors.

From a perusal of this document, I find that the Board of Visitors is authorized to direct the Astronomer Royal to make such observations as the Board shall think proper; to inspect the instruments, and to communicate with the Lords of the Admiralty upon the arrangements for keeping them in order; to make any suggestions to the Lords of the Admiralty touching the Observatory, and to require of the Astronomer Royal every three months, a copy of the observations made, with a view to printing them. I also gather that, for the efficient administration of all the duties of the Observatory, the Astronomer Royal is solely responsible to the Lords of the Admiralty.

† Report for 1867. Transactions of Sections, p. 95.

made to the Biological Section at Dundee; to which I would only add, that though the Zoological Collections are the finest in the world, and the Geological and Palæontological of prodigious extent and value, there are of the forty-five Trustees, only three who have any special knowledge whatsoever of the branches of science these collections illustrate; that since Sir Joseph Banks's death, nearly half a century ago, no Botanist has ever been appointed a Trustee, though the Banksian Herbarium and Botanical Library, then amongst the most valuable in Europe, were left by their owner to the nation; and, in fine, that the interests of Botany have by the Trustees been greatly neglected.

Much as has been written upon the uses of museums, I believe that the subject is still far from being exhausted, for in the present state of education in this country, these appear to me to afford the only means of efficiently teaching to schools the elements of Zoology and Physiology. I say in the present state of education, because I believe it will be many years before we have schoolmasters and mistresses trained to teach these subjects, and many more years before either provincial or private schools will be supplied with such illustrative specimens as are essential for the teacher's purposes.

Confining myself to the consideration of provincial and local museums, and their requirements for educational purposes, each should contain a connected series of specimens illustrating the principal and some of the lesser divisions of the Animal and Vegetable Kingdoms, so disposed in well-lighted cases, that an inquiring observer might learn therefrom the principles upon which animals and plants are classified, the relations of their organs to one another and to those of their allies, the functions of those organs, and other matters relating to their habits, uses, and place in the economy of nature. Such an arrangement has not been carried out in any museum known to me, though partially attained in that at Ipswich; it requires some space, many pictorial illustrations, magnified views of the smaller organs and their structure, and copious legible descriptive labels, and it should not contain a single specimen more than is wanted. The other requirements of a provincial museum are, complete collections of the plants and animals of the province, which should be kept entirely apart from the instructional series, and from everything else.

The Curator of the Museum should be able to give elementary demonstrations (not lectures, and quite apart from any powers of lecturing that he may possess) upon this classified series, to schools and others, for which a fee should be charged, which should go to the support of the Institution. And the museum might be available (under similar conditions of payment) for lectures and other demonstrations.

Did such an illustrated typical collection exist in your rich and well-arranged Norwich Museum, I am sure that there is not an intelligent schoolmaster in the city who would not see that his school profited by the demonstrator's offices, nor a parent who would grudge the trifling fee.

You boast of a superb collection of Birds of Prey; how much would the value of this be enhanced, were it accompanied by such an illustration of the nature, habits, and affinities of the Raptores, as might well be obtained by an exhibition of the skeleton and dissected organs of one Hawk and one Owl, so laid out and ticketed that a schoolboy should see the structure of their beak, feet, wings, feathers, bones, and internal organs—should see why it is that Hawks and Owls are preeminent amongst birds for powers of sight and of flight; for circling and for swooping; for rapacity, voracity, and tenacity

of life,—should see, in short, the affinities and special attributes of Birds of Prey*.

A series of illustrated typical specimens, occupying some 500 to 800 feet of wall space, would give at a glance a connected and intelligible elementary view of the classification and structure of the whole animal kingdom ; it would stand in the same relation to a complete Museum and Systema Naturæ as a chart on which the principal cities and coast-lines are clearly laid down does to a map crowded with undistinguishable details.

Excellent manuals of many branches of Zoology are now published which are invaluable to the advanced student and demonstrator, but from which the schoolboy recoils, who nevertheless would not refuse to accept objects and pictures as memory's pegs, on which to hang ideas, facts, and hard names. To schoolboys skeletons have often a strange fascination, and upon the structure of these the classification of the vertebrata much depends. What boy, who had ever been shown their skulls, would call a Seal or Porpoise a fish, or believe that a hedgehog could milk cows! as I am told many boys in Norfolk and Suffolk (as elsewhere) do implicitly believe.

Much of the utility of Museums depends on two conditions often strangely overlooked, viz. their situation, and their lighting and interior arrangements. The provincial Museum is too often huddled away, almost out of sight, in a dark, crowded, and dirty thoroughfare, where it pays dear for ground-rent, rates and taxes, and cannot be extended; the object, apparently, being to catch country people on market days. Such localities are frequented by the town's people only when on business, and when they consequently have no time for sight-seeing. In the evening, or on holidays, when they could visit the Museum, they naturally prefer the outskirts of the town to its centre.

Hence, too, the country gentry scarcely know of the existence of the Museum; and I never remember to have heard of a provincial Museum that was frequented by schools. I do not believe that this arises from indifference to knowledge on the part of the upper classes or of teachers, but to the generally uninstructive nature of the contents of these Museums, and their uninviting exterior and interior. There are plenty of visitors of all classes to the Museums at Kew, despite the counter attractions of the gardens ; and I know no more pleasing sight than these present on Sunday and Monday afternoons, when crowded by intelligent visitors, directing their children's attention to the ticketed objects in the cases.

The Museum should be in an open grassed square or park, planted with trees, in the town, or its outskirts ; a main object being to secure cleanliness, a cheerful aspect, and space for extension. Now vegetation is the best interceptor of dust, which is injurious to the specimens as well as unsightly, whilst a cheerful aspect and grass and trees will attract visitors, and especially families and schools.

If the external accessories of provincial Museums are bad, the internal arrangements are often worse ; the rooms are usually lighted by windows on one side only, so that the cases between the windows are dark, and those opposite the windows reflect the light when viewed obliquely, whilst the visitor standing in front is in his own light. For provincial Museums, where space is an object, there is no better plan than rectangular long rooms, with opposite windows on each side, and buttress cases projecting into the room between

* This, which refers to the teaching of Natural History, is an operation altogether apart from training the mind to habits of exact observation; which, as is now fully admitted, is best attained in schools by Professor Henslow's method of teaching Botany.

each pair of windows. This arrangement combines economy of space with perfect illumination, and affords facilities for classification*.

In respect of its Natural-History Collections, the position of the British Museum appears to me disadvantageous; it is surrounded by miles of streets, including some of the principal Metropolitan thoroughfares, which pour clouds of dust, and the products of coal-combustion into its area day and night; and I know few more disappointing sights, to me, than its badly lighted interior presents on a hot and crowded public holiday, when whole families from London and its outskirts flock to the building. Then young and old may be seen gasping for fresh air in its galleries, with no alternative but the hotter and dustier streets to resort to. How different it would be were these Collections removed to the townward end of one of the great parks! where spacious and well-lighted galleries could be built, amongst trees, grass, and fountains; and where whole families need not be cooped up for the day in the building, but avail themselves of the fresh air and its accessories at the same time as they profit by the Museum.

Norwich, I hear with surprise, has no Public Park worthy of the name. That she may soon have one should be the endeavour of every citizen, and to have a good instructional series added to your admirable Museum, and this transferred to the Park, should be the aspiration of all who are interested in the education and moral well-being of their townsmen.

My remarks on the British Museum convey no reflection on the able officers who have, in so short a time, formed this wonderful Collection. Lawrence, in his Lectures delivered in 1818, congratulates his audience on the formation of a Zoological Collection having just been determined upon; in 1838, when I first knew the Museum, in Old Montague House, I was told it ranked about the sixth in Europe—now, and for some years past, it has been considered to be the finest in the world. This is due to the energy and ability of the Keepers and Curators; and in mentioning them, I would wish to pay a passing tribute to the merits of the venerable Dr. Gray, who has devoted his life to the development of the Zoological Department, with a singleness of purpose, liberality, and zeal that are beyond all praise.

At the time when Old Montague House contained the National Collections, there was but one Museum in the Metropolis in which the Naturalist could study to much purpose; this was the Hunterian (belonging to the Royal College of Surgeons), then under the superintendence of the late Mr. Clift and of Professor Owen, the friend of my early youth, when preparing myself to accompany the Antarctic Expedition, and who instructed me in the use of that now unrivalled series of Catalogues, that owes so much to himself. From the Museum of the Royal College of Surgeons, the national and provincial Museums of England have much to learn and to copy; and, thanks to the wisdom and munificence of the Council of the College, and to the zeal

* Upon this plan the large Museum in Kew is built, where the three principal rooms are 70 ft. long by 45 ft. wide, and each accommodates 1000 square feet of admirably lighted cases, 600 or 700 feet of wall-room for pictures and for portraits of naturalists, besides two fireplaces, four entrances, and a well-staircase, 11 feet square. A circular building, with cases radiating from the wall between the windows, would probably be the best arrangement of all. A light spiral staircase in the centre would lead to the upper stories. Two or more of the bays might be converted into private rooms, without disturbing the symmetry of the interior or intercepting the lighting of the cases. The proportions of the basement and first floor might be such as to admit of additional stories being added, and the roof might be so constructed as to be removable without difficulty, when an additional story was required; furthermore, rectangular galleries might be built, radiating from the central building, and lighted by opposite windows, with buttress cases between each pair of windows.

and ability of the present Conservator, Mr. Flower, it retains the position it attained thirty years ago, of being the best and richest institution of the kind in Europe.

In my own special science, the greatest advances that have been made during the last ten years have been in the departments of Fossil Botany and Vegetable Physiology.

In the past history of the globe two epochs stand prominently forward (the Carboniferous and the Miocene) for the abundant materials they afford, and the light they consequently throw on the early conditions of the vegetable kingdom. Why plants should have been so much more abundantly preserved during these than during some of the intervening or earlier epochs, we do not rightly know; but the comparative poverty of the floras of these latter is amongst the strongest evidences of the imperfection of the geological record.

Our knowledge of coal plants, which, since the days of Sternberg, Brongniart, and Lindley and Hutton, has been chiefly advanced by Gœppert and Unger on the Continent, and by Dawson in Canada, has of late received very important accessions through the untiring energy of Mr. Binney, of Manchester, who has devoted nearly thirty years to the search for those rarely found specimens which exhibit the internal structure of the plant. His elaborate descriptions of the most abundant, and, before his researches, the least understood plant of the coal-measures, *Calamites*, have just appeared in the memoirs of the Palæontographical Society; and some of Mr. Binney's materials having also formed the subject of a very recent and valuable paper by Mr. Carruthers, of the British Museum, I may quote their joint results as one. These show that *Calamites* is an actual member of the existing family of Equisetaceæ, which contained previously but one genus, that of the common mare's tails of our river-banks and woods; as also, that nearly a dozen other genera of coal-measure plants may be referred to it. This affinity of *Calamites* had, indeed, been guessed at before, but the genera now referred to it, having been founded on mere fragments, were always doubtful; but the value of these positive identifications is none the less on this account. It may hereafter prove of some significance, that these *Calamites*, which, in the coal epoch, assumed gigantic proportions, and presented multitudinous forms and very varied organs of growth, are now represented by but one genus, differing most remarkably from its prototype in size, and in the simplicity and uniformity of its vegetable organs.

Passing to the Tertiary Flora, the labours of Count Saporta in France, of Gaudin and Strozzi, and of Massolonghi in Italy, of Lesquereux in America, and above all, of Heer in Switzerland, have within the last ten years accumulated a vast number of species of fossil plants; and if the determinations of the affinities of the majority are to be depended on, they prove the persistence, throughout the Tertiary strata, of many existing families and genera, and the rarity of others than these. Here, however, much value cannot be attached to negative evidence. Almost the only available materials for determining the affinities of the vast majority of these Tertiary plants are their mutilated leaves, and, unlike the bones of vertebrate animals and the shells of Mollusks, the leaves of individual plants are extremely variable in all their characters. Furthermore, the leaves of plants of different natural families, and of different countries, mimic one another to such a degree that, in the case of recent plants, every botanist regards these organs as most treacherous guides to affinity. Of the structural characters, which are drawn from the internal organs of plants, and especially from their fruits, seeds, and flowers,

few traces are to be found in fossils; and it is from these exclusively that the position of a recent plant in the vegetable kingdom can be certified. An instructive instance of over-reliance on leaves, and perhaps too on preconceived ideas, happened not long ago to a Palæontologist of such distinguished merit that his reputation cannot suffer from an allusion to it. In the course of his labours upon some imperfect specimens from a most interesting locality, he referred three associated impressions of fossil leaves to three genera, belonging to as many different families of plants; and was thus helped to what would have been some important conclusions as to the vegetation of the period in which they were deposited. A subsequent observer, who is a botanist but not a palæontologist, declares the leaves thus referred to three genera to be the three leaflets of the leaf of one plant, and this the common blackberry, which still grows on the spot. Which of the two is right, I do not say; the fact shows to what opposite conclusions different observers of the same fossil materials may be led.

In this most unreliable of sciences—Fossil Botany—we do but grope in the dark; of the thousands of objects we stumble against, we here and there recognize a likeness to what we have elsewhere known, and rely on external similitude for a helping hand to its affinities; of the great majority of specimens we know nothing for certain, and of no small proportion we are utterly ignorant. If, however, much is uncertain, all is not so, and the science has of late made sure and steady progress, and developed really grand results. Heer's labours on the Miocene and Pliocene floras especially, are of the highest value and interest; his conclusions regarding the flora of the Bovey Tracey Coal-beds (for the publication of which, in a form worthy of their value and of their author's merit, we are indebted to the wise liberality of Miss Burdett Coutts) are founded on a sufficient number of absolute determinations; and his more recent 'Flora Fossilis Arctica' threatens to create a revolution in Tertiary Geology. In this latter work Professor Heer shows, on apparently unassailable evidence, that forests of Austrian, American, and Asiatic trees flourished during the Miocene period in Iceland, Arctic Greenland, Spitzbergen, and the Polar American Islands, in latitudes where such trees could not now exist under any conceivable conditions or positions of land, sea, or ice; leaving little doubt that an arboreous vegetation once extended to the Pole itself. Discoveries such as these appear at first actually to retard the progress of science, by confounding all previous geological reasoning as to the climate and condition of the globe during the Tertiary epoch.

I have said that the greatest botanical discoveries made during the last ten years have been physiological; and I here alluded especially to the series of papers on the Fertilization of Plants which we owe to Mr. Darwin. You are aware that this distinguished naturalist, after accumulating stores of facts in geology and zoology during his circumnavigation of the globe with Captain Fitzroy, espoused the doctrine of the continuous evolution of life, and by applying to it the principles of Natural Selection, evolved his theory of the Origin of Species. Instead of publishing these views as soon as conceived, he devoted twenty more years to further observation, study, and experiment, with the view of maturing or subverting them. Amongst the subjects requiring elucidation or verification, were many that appertained to Botany, but which had been overlooked or misunderstood by botanical writers; and these he set himself to examine rigorously.

The first fruit of his labours was his volume on the 'Fertilization of Orchids,' undertaken to show that the same plant is never continuously fertilized by its own pollen, and that there are special provisions to favour

the crossing of individuals. As his study of the British species advanced, he became so interested in the number, variety, and complexity of the contrivances he met with, that he extended his survey to the whole family; and the result is a work, of which it is not too much to say that it has thrown more light upon the structure and functions of the floral organs of this immense and anomalous family of plants, than had been shed by the labours of all previous botanical writers. It has further opened up entirely new fields of research, and discovered new and important principles that apply to the whole vegetable kingdom.

This was followed by his paper on the well-known forms of the Primrose and Cowslip*, popularly known as the pin-eyed and thrum-eyed: these forms he showed to be sexual and complementary, their diverse functions being to secure, by their mutual action, full fertilization, which he proved could only take place through insect agency. In this paper he established the existence of homomorphic or legitimate, and heteromorphic or illegitimate unions amongst plants, and detailed some curious observations on the structure of the pollen. The results of this, perhaps more than any other of Mr. Darwin's papers, took botanists by surprise, the plants being so familiar, their two forms of flower so well known to every intelligent observer, and his explanation so simple. For my own part I felt that my botanical knowledge of these homely plants had been but little deeper than Peter Bell's, to whom

> A primrose by the river's brim
> A yellow primrose was to him,
> And it was nothing more.

Analogous observations on the dimorphism of flax and its allies† formed a subsequent paper; during the course of which observations he made the wonderful discovery that, in the common flax, the pollen of one form of flower is absolutely impotent when applied to its own stigma, but invariably potent when applied to the stigma of the other form of flower; yet the pollens and stigmas of the two kinds are utterly undistinguishable under the highest powers of the microscope.

His third investigation was a very long and laborious one on the Common Loosestrife‡ (*Lythrum salicaria*), which he showed to be trimorphic; this one species having three kinds of flowers, all annually abundantly produced, and as different as if they belonged to different species; each flower has, further, three kinds of stamens, differing in form and function. We have in this plant, then, six kinds of pollen, of which five at least are essential to complete fertility, and three distinct forms of style. To prove these various differences, and that the co-adaptation of all these stamens and pistils was essential to complete fertility, Mr. Darwin had to institute eighteen sets of observations, each consisting of twelve experiments, 216 in all. Of the labour, care, and delicacy required to guard such experiments against the possibility of error, those alone can tell who experimentally know how difficult it is to hybridize a large-flowered plant of simple form and structure. The results in this case, and in those of a number of allied plants experimented on at the same time, are such as the author's sagacity had predicted; the rationale of the whole was demonstrated, and he finally showed, not only how nature might operate in bringing these complicated modifications into harmonious operation, but how through insect agency she does do this, and also why she does it.

* Journal of the Linnean Society of London, vol. vi. p 77.
† Ibid. vol. vii. p. 69.
‡ Ibid. vol. viii. p. 169.

It is impossible even to enumerate here the many important generalizations that have followed from these and other papers of Mr. Darwin on the fertilization of plants; some that appear to be commonplace at first sight are really the most subtle, and like many other apparent commonplaces, are what, somehow, never occur to commonplace minds: as, for instance, that all plants with conspicuously coloured flowers or powerful odours or honeyed secretions are fertilized by insects; all with inconspicuous flowers, and especially such as have pendulous anthers or incoherent pollen, are fertilized by the wind: whence he infers that, before honey-feeding insects existed, the vegetation of our globe could not have been ornamented with bright-coloured flowers, but consisted of such plants as pines, oaks, grasses, nettles, &c.

The only other botanical paper of Mr. Darwin to which I can especially allude, is that "On the Habits and Movements of Climbing Plants" *, which is a most elaborate investigation into the structure, modification, and functions of the various organs by which plants climb, twine, and attach themselves to foreign objects. In this he reviews every family in the vegetable kingdom, and every organ used by any plant for the above purposes. The result places the whole subject in a totally new light. The guesses, crude observations, and abortive experiments that had disfigured the writings of previous observers are swept away; organs, structures, and functions, of which botanists had no previous knowledge, are revealed to them; and the whole investigation is made as clear as it is interesting and instructive.

The value of these discoveries, which add whole chapters to the principles of botany, is not theoretical only: already the horticulturist and agriculturist have begun to ponder over them, and to recognize in the failure of certain crops, the operation of laws that Mr. Darwin first laid down. What Faraday's discoveries are to telegraphy, Mr. Darwin's will assuredly prove to rural economy, in its widest sense and most extended application.

Another instance of successful experiment in Physiological Botany is Mr. Herbert Spencer's observations on the circulation of the sap and the formation of wood in plants †. As is well known, the tissues of herbs, shrubs, and trees, from the tips of their roots to those of their petals and pistils, are permeated by tubular vessels. The functions of these have been hotly disputed, some physiologists affirming that they convey air, others fluids, others gases, and still others assigning to them far-fetched uses, of a wholly different nature. By a series of admirably contrived and conducted experiments, Mr. Spencer has not only shown that these vessels are charged at certain seasons of the year with fluid, but that they are intimately connected with the formation of wood. He further investigates the nature of the special tissues concerned in this operation, and shows not merely how they may act, but to a great extent how they do act. As this paper will, I believe, be especially alluded to by the President of the Biological Section, I need dwell no further on it here, than to quote it as an example of what may be done by an acute observer and experimentalist, versed in Physics and Chemistry, but above all, thoroughly instructed in scientific methods.

Mr. Darwin's recent volumes "On Animals and Plants under Domestication," contain a harvest of data, observations, and experiments, such as assuredly no one but himself could have gathered. It is hard to say whether this book is most remarkable for the number and value of the new facts it discloses, or for its array of small forgotten or overlooked observations,

* Journal of the Linnean Society, vol. ix. p. 1.
† Linnean Transactions, vol. xxv. p. 405.

neglected by some naturalists, and discarded by others, which, under his mind and eye, prove to be of first-rate scientific importance. An eminent surgeon and physiologist (Mr. James Paget) remarked to me, *à propos* of these volumes, that they exemplify in a most remarkable manner that power of utilizing the waste materials of other men's laboratories which is a very characteristic feature of their author. As one of those *pièces justificatives* of his previous work, 'The Origin of Species,' which have been waited for so long and impatiently, these volumes will probably have more than their due influence; for the serried ranks of facts in support of his theories which they present, may well awe many a timid naturalist into swallowing more obnoxious doctrines than that of natural selection.

It is in this work that Mr. Darwin expounds his new hypothesis of Pangenesis, which certainly correlates, and may prove to contain the rationale of all the phenomena of reproduction and of inheritance. You are aware that every plant or animal commences its more or less independent life as a single cell, from which is developed an organism more or less closely similar to its parent. One of the most striking examples I can think of is afforded by a species of Begonia, the stalks, leaves, and other parts of which are superficially studded with loosely attached cellular bodies. Any one of those bodies, if placed under favourable conditions, will produce a perfect plant, similar to its parent. You may say that these bodies have inherited the potentiality to do so; but this is not all, for every plant thus produced, in like manner developes on its stalks leaves and myriads of similar bodies, endowed with the same property of becoming new plants, and so on, apparently interminably. Therefore the original cell that left the grand parent, not only carried with it this so-called potentiality, but multiplied it and distributed it with undiminished power through the other cells of the plant produced by itself, and so on, for countless generations. What is this potentiality? and how is this power to reproduce thus propagated, so that an organism can, by single cells, multiply itself so rapidly, and within very narrow limits, so surely and so interminably? Mr. Darwin suggests an explanation, by assuming that each cell or fragment of a plant (or animal) contains myriads of atoms or gemmules, each of which gemmule he supposes to have been thrown off from the separate cells of the mother-plant, the gemmules having the power of multiplication, and of circulating throughout the plant: their future development he supposes to depend on their affinity for other partially developed cells in due order of succession. Gemmules which do not become developed, may, according to his hypothesis, be transmitted through many succeeding generations, thus enabling us to understand many remarkable cases of reversion or atavism. Hence the normal organs of the body have not only the representative elements of which they consist diffused through all the other parts of the body, but the morbid states of these, as hereditary diseases, malformations, &c., all actually circulate in the body as morbid gemmules.

As with other hypotheses based on the assumed existence of structures and elements that escape our senses, by reason of their minuteness or subtlety, this of Pangenesis will approve itself to some minds and not to others. To some these inconceivably minute circulating gemmules will be as apparent to the mind's eye as the stars of which the Milky Way is composed; others will prefer embodying the idea in such a term as potentiality, a term which conveys no definite impression whatever, and they will like it none the less on this account.

Whatever be the scientific value of these gemmules, there is no question

but that to Mr. Darwin's enunciation of the doctrine of Pangenesis we owe it that we have the clearest and most systematic *résumé* of the many wonderful phenomena of reproduction and inheritance that has yet appeared; and against the guarded entertainment of the hypothesis, or speculation if you will, as a means of correlating these phenomena, nothing can be urged in the present state of science. The President of the Linnean Society, a proverbially cautious naturalist, thus well expresses his own ideas of Pangenesis:—"If," he says, "we take into consideration how familiar mathematical signs and symbols make us with numbers and combinations, the actual realization of which is beyond all human capacity, how inconceivably minute must be those emanations which most powerfully affect our sense of smell and our constitutions, and if, discarding all preventions, we follow Mr. Darwin, step by step, applying his suppositions to the facts set before us, we must, I think, admit that they may explain some, and are not incompatible with others; and it appears to me that Pangenesis will be admitted by many as a provisional hypothesis, to be further tested and to be discarded only when a more plausible one shall be brought forward."

Ten years have elapsed since the publication of 'The Origin of Species by Natural Selection,' and it is therefore not too early now to ask what progress that bold theory has made in scientific estimation. The most widely circulated of all the journals that give science a prominent place on their title-pages, the 'Athenæum,' has very recently told to every country where the English language is read, that Mr. Darwin's theory is a thing of the past, that Natural Selection is rapidly declining in scientific favour, and that, as regards the above two volumes on the variations of animals and plants under domestication, they "contain nothing more in support of origin by selection, than a more detailed reasseveration of his guesses founded on the so-called variations of pigeons."

Let us examine for ourselves into the truth of these inconsiderate statements. Since the 'Origin' appeared ten years ago, it has passed through four English editions, two American, two German, two French, several Russian, a Dutch, and an Italian; whilst of the work on Variation, which first left the publisher's house not seven months ago, two English, a German, Russian, American, and Italian editions are already in circulation. So far from Natural Selection being a thing of the past, it is an accepted doctrine with almost every philosophical naturalist, including, it will always be understood, a considerable proportion who are not prepared to admit that it accounts for all Mr. Darwin assigns to it.

Reviews on 'The Origin of Species' are still pouring in from the continent; and Agassiz, in one of the addresses which he issued to his collaborateurs on their late voyage to the Amazons, directs their attention to this theory as a primary object of the expedition they were then undertaking. I need only add, that of the many eminent naturalists who have accepted it, not one has been known to abandon it; that it gains adherents steadily; and that it is *par excellence* an avowed favourite with the rising schools of naturalists; perhaps, indeed, too much so, for the young are apt to accept such theories as articles of faith, and the creed of the student is but too likely to become the shibboleth of the future professor.

The scientific writers who have publicly rejected one or both of the theories of continuous evolution and of natural selection, take their stand upon physical or metaphysical grounds, or both. Of those who rely on the metaphysical, their arguments are usually strongly imbued with theological prejudice and even odium, and as such are beyond the pale of scientific

criticism. Having myself been a student of Moral Philosophy in a northern University, I entered on my scientific career full of hopes that metaphysics would prove a useful mentor, if not a guide in science. I soon, however, found that it availed me nothing, and I long ago arrived at the conclusion, so well put by Agassiz, when he says, "we trust that the time is not distant when it will be universally understood that the battle of the evidences will have to be fought on the field of Physical Science, and not on that of Metaphysical" *. Many of the metaphysicians' objections have been controverted by that champion of Natural Selection, Mr. Darwin's true knight, Alfred Wallace, in his papers on "Protection"† and "Creation by Law"‡, &c., in which the doctrines of "Continual Interference," the "Theory of Beauty," and kindred subjects, are discussed with admirable sagacity, knowledge, and skill. But of Mr. Wallace and his many contributions to philosophical biology, it is not easy to speak without enthusiasm; for, putting aside their great merits, he, throughout his writings, with a modesty as rare as I believe it to be in him unconscious, forgets his own unquestioned claims to the honour of having originated, independently of Mr. Darwin, the theories which he so ably defends.

On the score of geology, the objectors chiefly rely on the assumed perfection of the geological record; and since almost all who believe in its imperfection, and many of the other school, accept the theories both of evolution and natural selection, wholly or in part, there is no doubt that Mr. Darwin claims the great majority of geologists. Of these, one is in himself a host, the veteran Sir Charles Lyell, who, after having devoted whole chapters of the first editions of his 'Principles' to establishing the doctrine of special creations, abandons it in the 10th edition, and this, too, on the showing of a pupil; for, in the dedication of his earliest work, 'The Naturalist's Voyage,' to Sir C. Lyell, Mr. Darwin states that the chief part of whatever merit he or his works may possess, has been derived from studying the 'Principles of Geology.' I know no brighter example of heroism, of its kind, than this, of an author thus abandoning, late in life, a theory which he had for forty years regarded as one of the foundation stones of a work that had given him the highest position attainable amongst contemporary scientific writers. Well may he be proud of a superstructure, raised on the foundations of an insecure doctrine, when he finds that he can underpin it and substitute a new foundation; and after all is finished, survey his edifice, not only more secure, but more harmonious in its proportions than it was before; for assuredly the biological chapters of the tenth edition of the 'Principles' are more in harmony with the doctrine of slow changes in the history of our planet, than were their counterparts in the former editions.

To the astronomers' objections to these theories I turn with diffidence; they are strenuously urged in what is in my opinion the cleverest critique of them that I have hitherto met with, and which appeared in the North British Review. It is anonymous, I am wholly ignorant of its author, and I regret to find that, in common with the few other really able hostile critiques, it is disfigured by a dogmatism that contrasts unfavourably with Mr. Darwin's considerate treatment of his opponents' methods and conclusions. The author starts, if I read him aright, by professing his unfamiliarity with the truth and extent of the facts upon which the theories of Evolution and Natural Selection are founded, and goes on to say, that "the superstructure based on

* Agassiz on the Contemplation of God in the Kosmos. Christian Examiner, 4th Series, vol. xv. p. 2.

† Westminster Review.

‡ Journal of Science, October, 1867.

them may be discussed apart from all doubts as to the fundamental facts." The liberty thus to discuss no one may dispute or curtail, but the biologist will ask, to what end can discussion lead? Who would attach much weight to the verdict of a judge passed on evidence of which he knew neither the truth nor the extent? As well might a boy guiltless of mathematics, set himself to test the 47th proposition of the 1st book of Euclid, by constructing paper squares corresponding to the sides of a right-angled triangle, then cutting up the smaller squares, try to fit the pieces into the larger, and failing to do this with exactitude, conclude of the problem, as the reviewer does of the theory, that it is "an ingenious and plausible speculation, marking at once the ignorance of the age and the ability of the philosopher."

The most formidable argument urged by the reviewer is, that "the age of the inhabited world as calculated by solar physics, is proved to have been limited to a period wholly inconsistent with Darwin's views." This would be a valid objection if these views depended on those of one school of geologists; and if the 500,000,000 years, which the reviewer adopts as the age of the world, were, as an approximate estimate, accepted by either astronomers or physicists. But, in the first place, the reviewer assumes that the rate of change in the condition of the earth's surface was vastly more rapid at the beginning than now, and has gradually slackened since; but overlooks the consequence, that according to all Mr. Darwin's principles the operations of natural selection must in such cases have been formerly correspondingly more rapid: and in the second, are these speculations as to the solidity of the earth's crust dating back only 500,000,000 years, to be depended upon? In his great work, the author* quoted for these numbers, gives as possible limits 20,000,000, or 400,000,000 years, whilst other philosophers assign to the habitable globe an age far exceeding the longest of these periods. Surely, in estimates of such a nature as the above, which are calculated from data themselves in a great degree hypothetical, there are no principles upon which we are warranted in assuming the speculations of the astronomer to be more worthy of confidence than those of the biologist.

A former most distinguished President, and himself an astronomer, Professor Whewell, has said of astronomy that "it is not only the queen of sciences, but the only perfect science, the only branch of human knowledge in which we are able fully and clearly to interpret nature's oracles, so that by that which we have tried we receive a prophecy of that which is untried"†. Now, whilst fully admitting, and proudly as every scientific man ought, that astronomy is the most certain in her methods and results of all the sciences, that she has called forth some of the highest efforts of the intellect, and that her results far transcend in grandeur those of any other science, I think we may hesitate before we therefore admit her queenship, her perfection, or her sole claims to interpretation and to prophecy. Her methods are those of the mathematicians; she may call Geometry and Algebra her handmaidens, but she is none the less their slave. No science is really perfect, certainly not that which lately erred nearly 4,000,000 miles in so fundamental a datum as the earth's distance from the sun. Have Faraday and Von Baer interpreted no oracles of nature fully and clearly? Have Cuvier and Dalton not prophesied, and been true prophets? Claims to queenship do not accord with the spirit of science; rather would I liken the domain of natural knowledge to a hive, in which every comb is a science, and truth the one queen over them all.

* Thomson and Tait, Treatise on Natural Philosophy, vol. i. p. 716.
† Rev. W. Whewell. Reports, 1833, p. xiii.

It remains to say a few words on some prospects which this Norwich Meeting opens.

A new science has dawned upon us, that of the Early History of Mankind. Prehistoric archæology (including as it does the origin of language and of art) has been the latest to rise of a series of luminaries that have dispelled the mists of ages and replaced time-honoured traditions by scientific truths. Astronomy, if not the queen, yet the earliest of sciences, first snatched the torch from the hands of dogmatic teachers, tore up the letter and cherished the spirit of the law. Geology next followed, but not till two centuries had elapsed, nor indeed till this our day, in divesting religious teaching of many cobwebs of scientific error. It has told us that animal and vegetable life preceded the appearance of man on the globe, not by days but by myriads of years; and how late this knowledge came we may gather from the fact that Lawrence in his previously quoted lectures *, delivered so late as 1818, says of the extinct races of animals, "that their living existence has been supposed, with considerable probability, to be of older date than the formation of the human race."

And, last of all, this new science proclaims man himself to have inhabited this earth for perhaps many thousands of years before the historic period—a result little expected less than thirty years ago, when the Rev. W. V. Harcourt, in his address to the Association at Birmingham †, observed that "Geology points to the conclusion, that the time during which mankind has existed on the globe, cannot materially differ from that assigned by Scripture," referring, I need not say, to the so-called Scripture chronology, which has no warrant in the Old Testament, and which gives 5874 years as the age of the inhabited globe.

Pre-historic Archæology now offers to lead us where man has hitherto not ventured to tread. Can we, whilst truthfully and fearlessly pursuing this inquiry, separate its physical from its spiritual aspect? will be the uppermost thought in the minds of many here present. To separate them is, I believe, indeed impossible, but to search out common truths that underlie both is permitted to all. Mr. Disraeli ‡ has well said of Truth, that it is the sovereign passion of mankind. And it should be emphatically so in the minds engaged in this search, where religion and science should speak peace to one another, if they are to walk hand in hand in this our day and generation.

A great deal has of late been said and written about the respective attitudes of Religion and Science; and my predecessor, the Duke of Buccleuch, dwelt on this in his address last year with great good sense and good taste, and pointed out how much the progress of knowledge depended on this attitude being mutually considerate and friendly. During the first decades of my scientific life, science was rarely, within my experience, heard of from the pulpits of these islands: during the succeeding, when the influence of the 'Reliquiæ Diluvianæ' and the Bridgewater Treatises was still felt, I often heard it named, and always welcomed. Now, and of late years, science is more frequently named than ever, but too often with dislike or fear, rather than with trust and welcome.

The Rev. Dr. Hanna, in an eloquent and candid contribution to the 'Contemporary Review'§, has adduced a long list of eminent clergymen of various denominations, who have adorned science by their writings, and religion by their lives. I do not ignore their contributions, still less do I overlook the many brilliant examples of educated preachers who give to science the respect

* Lectures on Physiology, Zoology, &c., p. 52. † Report, p. 17.
‡ Life of Lord George Bentinck. § Vol. vi. No. 21, September, 1867.

due to it. But Dr. Hanna omits to observe that the majority of these honoured contributors were not religious teachers in the ordinary sense of the term; nor does he tell us in what light many of their scientific writings were regarded by a large body of their brother clergymen, those resident in the country especially, from whom alone an overwhelming proportion of the population ever hear the name of science.

To return, let each pursue the search for truth, the archæologist into the physical, the religious teacher into the spiritual history and condition of mankind. It will be in vain that each regards the other's pursuit from afar, and turning the object-glass of his mind's telescope to his eye, is content when he sees how small the other looks.

To search out the whence and whither of his existence, is an unquenchable instinct of the human mind; to satisfy it, man in every age, and in every country, has adopted creeds that embrace his past history and his future being, and has eagerly accepted scientific truths that support the creeds; and but for this unquenchable instinct, I for one believe that neither religion nor science would have advanced so far as they have into the hearts of any people. Science has never in this search hindered the religious aspirations of good and earnest men; nor have pulpit cautions, which are too often ill-disguised deterrents, ever turned inquiring minds from the revelations of science.

A sea of time spreads its waters between that period to which the earliest traditions of our ancestors point, and that far earlier period, when man first appeared upon the globe. For his track upon that sea man vainly questions his spiritual teachers. Along its hither shore, if not across it, science now offers to pilot him. Each fresh discovery concerning pre-historic man is as a pier built on some rock its tide has exposed, and from these piers arches will one day spring that will carry him further and further across its depths. Science, it is true, may never sound the depths of that sea, may never buoy its shallows, or span its narrowest creeks; but she will still build on every tide-washed rock, nor will she deem her mission fulfilled till she has sounded its profoundest depths and reached its further shore, or proved the one to be unfathomable and the other unattainable, upon evidence not yet revealed to mankind. And if in her track she bears in mind that it is a common object of religion and of science to seek to understand the infancy of human existence, that the laws of mind are not yet relegated to the domain of the teachers of physical science, and that the laws of matter are not within the religious teacher's province, these may then work together in harmony and with good will.

But if they would thus work in harmony, both parties must beware how they fence with that most dangerous of all two-edged weapons, Natural Theology; a science, falsely so called, when, not content with trustfully accepting truths hostile to any presumptuous standard it may set up, it seeks to weigh the infinite in the balance of the finite, and shifts its ground to meet the requirements of every new fact that science establishes, and every old error that science exposes. Thus pursued, Natural Theology is to the scientific man a delusion, and to the religious man a snare, leading too often to disordered intellects and to atheism.

One of our deepest thinkers *, Mr. Herbert Spencer, has said:—"If religion and science are to be reconciled, the basis of the reconciliation must be this deepest, widest, and most certain of facts, that the power which the universe manifests to us is utterly inscrutable." The bonds that unite the

* First Principles, by Herbert Spencer, ed. ii. p. 16.

physical and spiritual history of man, and the forces which manifest themselves in the alternate victories of mind and of matter over the actions of the individual, are, of all the subjects that physics and psychology have revealed to us, the most absorbing; and are, perhaps, utterly inscrutable. In the investigation of their phenomena is wrapped up that of the past and the future, the whence and the whither, of his existence; and after a knowledge of these the human soul still yearns, and thus passionately cries, in the words of a living poet:—

"To matter or to force
The all is not confined;
Beside the law of things
Is set the law of mind;
One speaks in rock and star,
And one within the brain,
In unison at times,
And then apart again;
And both in one have brought us hither,
That we may know our whence and whither.

"The sequences of law
We learn through mind alone;
We see but outward forms,
The soul the one thing known;—
If she speak truth at all,
The voices must be true
That give these visible things,
These laws their honour due,
But tell of One who brought us hither,
And holds the keys of whence and whither.

* * * * * *

"He in His science plans,
What no known laws foretell;
The wandering fires and fix'd
Alike are miracle:
The common death of all,
The life renew'd above,
Are both within the scheme
Of that all-circling love.
The seeming chance that cast us hither,
Accomplishes His whence and whither" *.

* The Reign of Law, by F. T. Palgrave. Macmillan's Magazine, March 1867.

ERRATA.

P. 399, lines 20–22, *for* maximum still occurs . . . November *read* maxima have occurred on the 6th–7th of December, but of which symptoms (Greg's A_{16}) can be distinguished as early as the 23rd of November.

P. 399, lines 23, 24, *for* on . . . on . . . date *read* in . . . in . . . month.

P. 399, line 27, *for* May *read* March or April.

P. 400, last line, *for* Chapelas *read* Chapelas-Coulvier-Gravier.

P. 403, line 4 from bottom, for *Max.* 1848–52 read *Max.* Dec. 6–7, 1798 (?), 1838, 1847, 1848–52. Perhaps connected with Biela's comet.

P. 407, line 11 from bottom, *for* 12th of December, including, perhaps, *read* beginning of December, including.

P. 407, last line, *add*, and Father Secchi that of "uranoliths" to designate aërolites.

ERRATA

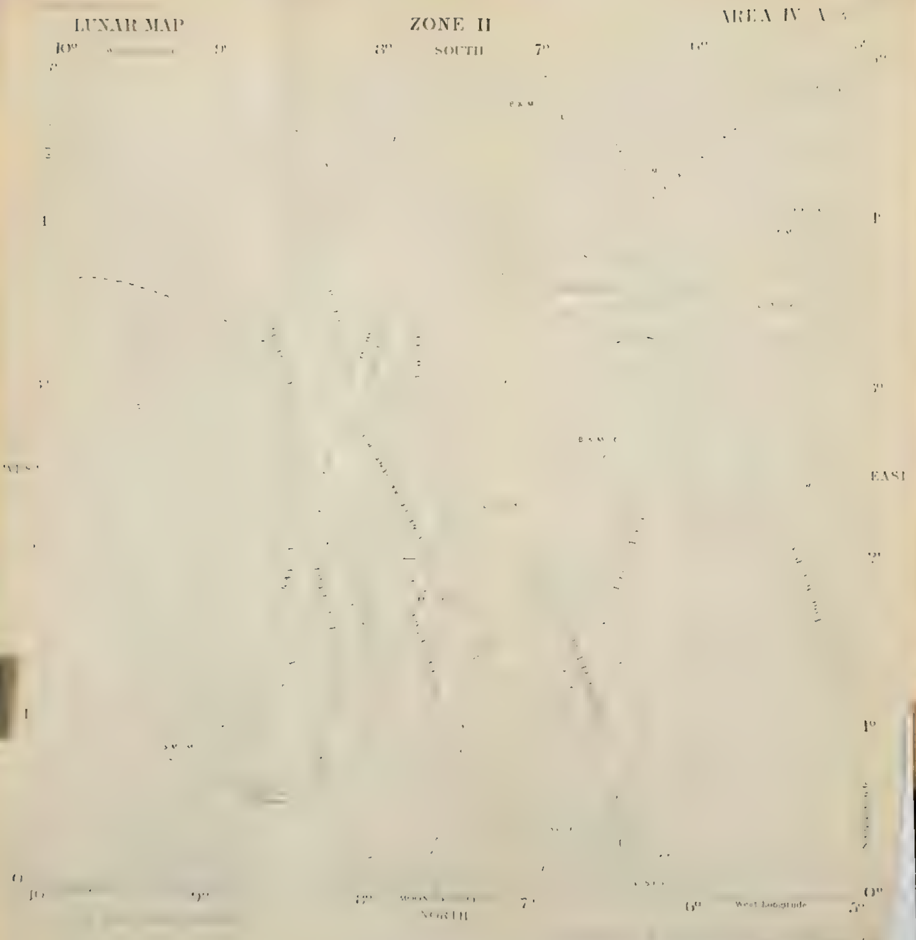
In Transactions of the Sections for 1866.

P. 65, line 12 from bottom, *for* Vaginicula *read* Vaginulina.

„ line 10 from bottom, *for* Protalia *read* Rotalia.

... may be laid broad and deep,

1868. B


LUNAR MAP
ZONE II
SOUTH
EAST
NORTH

REPORTS

ON

THE STATE OF SCIENCE.

Report of the Lunar Committee for Mapping the Surface of the Moon. Drawn up by W. R. Birt, *at the request of the Committee, consisting of* James Glaisher, *F.R.S.*, Lord Rosse, *F.R.S.*, Lord Wrottesley, *F.R.S.*, Sir J. Herschel, *Bart.*, *F.R.S.*, Professor Phillips, *F.R.S.*, Rev. C. Pritchard, *F.R.S.*, W. Huggins, *F.R.S.*, Warren De La Rue, *F.R.S.*, C. Brooke, *F.R.S.*, Rev. T. W. Webb, *F.R.A.S.*, J. N. Lockyer, *F.R.A.S.*, Herr Schmidt, *and* W. R. Birt, *F.R.A.S.*

[Plate I.]

In presenting the annual Report of the proceedings of the Lunar Committee, the usual course has been to specify the amount of work done under the respective heads of Registration of Objects, the progress of the outline map, the results of observation, and a notice of any striking phenomenon that may have come under the cognizance of the Committee. Previously to entering upon the above-mentioned subjects, the Committee have the pleasure to announce that, by the kindness of Edward Crossley, Esq., of Halifax, who has lent his equatorial of 7·3 in. aperture and 12 feet focal length expressly for this work, they are in a better position not only for more effectively constructing the map and compiling the catalogue, but also for examining the observations which are transmitted to them from time to time. With this view the telescope has been mounted at Walthamstow, and has received several accessions to render it more suitable for the work. The number of eyepieces capable of being used with it is twelve. Mr. Birt (who is now engaged in examining in detail the areas already issued, in observing such spots as *Linné*, Alpetragius *d*, IV A^{a} 17, IV A^{ς} 39, and others that present any remarkable phenomena, and also in checking zone and other observations) reports that its performance is very satisfactory.

The acquisition of this instrument, the zones at present under systematic observation, and particularly the *increased* number of observations (see *post*, pp. 3 and 4) requisite to elucidate questions that may be raised relative to the physical aspect and condition of the moon's surface induce the hope that more observers will join in the work, especially gentlemen in possession of powerful optical means. The Committee are desirous that the basis of observation of the physical aspect of the moon's surface may be laid broad and deep,

that the superstructure may be characterized by accuracy and precision as well in recording detail as in discussing observations, and that the results arrived at may be beyond dispute and fully capable of testing any question that may arise as to the state of the moon's surface.

Registration of Objects.—During the past Association year, the registration of objects has proceeded in conformity with the mode adopted in previous years. The numbers are as follows:—

	553	on	128	areas in Quadrant	I.
	353	,,	86	,, ,,	II.
	215	,,	57	,, ,,	III.
	642	,,	62	,, ,,	IV.
Total	1763		333		

Outline Map.—The drawing of area IV A^{β} has been prepared, engraved, and a number printed for distribution; also a catalogue of 99 objects upon this area has been compiled and printed. Several corrections and additions to areas IV A^{a} and IV A^{ζ} have been made; so that the number of objects inserted on the maps, either engraved or in MS., and included in the Catalogue, amounts to 337, which is a trifle less than $\frac{1}{5}$ of the number inserted in the folio registers.

In preparing the catalogue, every care has been taken to meet the growing requirements of selenographical research. The doubts that surround the labours of earlier selenographers, as to correctness of details, many delineations being conventional rather than actual, combined with the absence of precision in describing lunar features, render it essential that the description of an object should, if possible, embody its principal characteristics at a given epoch. The compilation of the catalogue was commenced with this view; and it has been steadily maintained in the portion accompanying this Report as well in the previous ones, each description being as much as possible equivalent to a trustworthy observation.

As the positions of objects on the outline map are for mean libration, it may be well to mention that the moon attains a state of mean libration (nearly) in 1868 on October $24^{d}\ 20^{h}\ 8^{m}$.

Results of Observations.—More than thirty-two gentlemen have undertaken the examination of special zones or particular objects. The work accomplished in accordance with the instructions in the letterpress of IV A^{a}, IV A^{ζ} is as follows:—106 objects in the three areas have been independently identified, *i. e.* originally laid down from De La Rue's and Rutherford's photograms, or from observations made by the Secretary; they have been reobserved by gentlemen in whose zones they occur. In seven cases the observations were made by *four* independent observers, in six cases they were made by *three* independent observers, in 32 cases by two, and in 61 by one observer only. Appendix II. contains the Association symbols of these objects, with such notes as may be deemed necessary, also the additions to the map and catalogue. See *post*, pp. 40 and 41.

Observations of this kind may be greatly facilitated by choosing "test objects" in accordance with the suggestion of Mr. Slack, who recommends "Crater-Row" (IV $A^{\zeta}\,13$, IV $A^{\zeta}\,14$, IV $A^{\zeta}\,15$, IV $A^{\zeta}\,18$, IV $A^{\zeta}\,19$, five craterlets) as very suitable for area IV A^{ζ}. If the craterlets, especially IV $A^{\zeta}\,18$ and IV $A^{\zeta}\,19$, come out sharply and well defined, and can be seen distinctly and without tremor, the earth's atmosphere is in a good state for observation; and if, *at the same time, neighbouring objects* are indistinct, hazy, and ill-defined (phenomena that may be occasionally noticed), then it would appear that this

indistinctness is not occasioned by the state of the earth's atmosphere, but by some other agency.

Particular Phenomena.—Under this head may be classed observations of *Linné*, the spot IV A^{α} 17, IV $A\varsigma$ 39, *Alpetragius d*, and others of the same kind (see *post*, pp. 29 and 41). From my own observations, and from several others which have come to hand, it appears that those phenomena that have been considered indicative of "change" have been mostly characterized by occasional indistinctness of the objects observed, contributing to the suspicion that such objects have either disappeared, or that new craters have been formed. Without a very careful discussion in connexion with solar altitudes and azimuths, and the difference between the angle of incidence *on* the moon's surface and the angle of reflexion *from* the moon's surface, which is equal to the supplement of the angle ☾ $-$ ☉, it is very difficult to refer such phenomena to their legitimate sources.

Change.—The question of "change" on the moon's surface still remains undecided. Although the circumstances associated with the earlier records and delineations fail to invest them with that authority which is necessary to a decision of the question, they are nevertheless exceedingly important, and a careful study of the works of the four leading selenographers, Schröter, Lohrmann, Beer and Mädler, and Schmidt, is essential to a competent knowledge of the surface of our satellite. The "facts" recorded by them are very numerous. These facts, compared with the results obtained by the aid of photography, and with those of recent observation, must tend in no small degree to advance selenographical knowledge.

In the course of such a comparison many differences will be found. Earlier delineations and photograms will not agree; and in seeking for an explation of such differences, we are naturally led to regard variations of distance, libration, and illumination as fruitful sources of apparent change. It has been a matter of solicitude in preparing the areas and catalogue already issued, to define the extent of apparent change produced by alterations of distance and by libration, which near the middle of the moon is but small. Apparent changes occasioned by differences in the angles of illumination are not so easily dealt with. Before we can venture to express an opinion on a supposed apparent change as dependent upon the sun's altitude above and his azimuth at any particular spot, it is manifestly necessary to know *all* the changes of appearance which the object undergoes as the sun rises higher above it, culminates, and declines. This necessarily involves a considerable amount of calculation, especially if the three coordinates are employed, viz. the latitude of the spot, the sun's declination, and his hour-angle. Some approximation, however, may be made to the sun's altitude at intervals of 12 hours, from his rising at the moon's equator, on a point at which the longitudes of the terminator and the spot agree, to his meridian passage at the same point. I am accordingly preparing a set of Tables of Solar Altitudes at intervals of twelve hours (nearly) for every five degrees of lunar latitude, and also for the solstices and equinoxes at each. The Tables for the Equator, 5°, and 10° of latitude will be found on pp. 10 and 11.

Before a correct judgment can be formed on the gradations of appearance presented by any one spot as the sun's altitude increases and declines, it is necessary to obtain observations of that spot at intervals of at least 12 hours. The greatest change of altitude during this interval is a little more than 6° on the equator. This change in 12 hours decreases as a spot is situated N. or S. of the equator. To obtain a sufficient number of observations for this purpose, observers must confine in some degree their attention to parti-

cular objects for many lunations, so that a normal character of the appearance of a certain spot with any given mean solar altitude may be determined. Ten observations for each interval would be necessary before the normal character could be considered sufficiently ascertained, in order to distinguish between apparent and real change. This process is clearly a work of time; it is nevertheless absolutely necessary to settle such a question as that which has been raised in respect of *Linné*. The observations of this spot are now numerous; various opinions have been expressed with regard to it; but as yet they are inconclusive, the observations being little better than "raw material." When they have undergone the examination above proposed, we may be the better able to arrive at some conclusion respecting *Linné*.

In the course of "Zone Observations," and therefore entirely originating with the labours of this Committee, another spot of apparently the same nature as *Linné*, so far as recent observations are concerned, has been detected. Not previously known, it has been described under the symbols IV A^{α} 17, IV A^{ζ} 39 as a "bright spot." The Rev. W. O. Williams of Pwllheli, in whose pair of subzones it occurs (see letterpress IV A^{α}, IV A^{ζ}, pp. 5 & 6, and Report British Association, 1866, pp. 241, 242), has fully confirmed an observation which I made in 1867 on May 11, when I saw it as a shallow crater. Mr. Williams has observed it as a crater with a central cone, Mr. Baxendell has seen it as a well-marked shallow crater, and Mr. Williams has frequently seen it as a bright white spot. I have lately ascertained, by the aid of the Crossley Equatorial, that it is situated on the summit of a mountain-range, and is opened in an irregular depression on this summit. For a digest of the existing observations arranged in order of solar altitudes see p. 29. They are, however, too few in number to determine at present the normal character for each group of 6° of altitude; but there are a few differences of appearance with similar altitudes which claim attention.

Probably the only circumstance that we are acquainted with as connected with our own atmosphere capable of rendering an object on the moon's surface *indistinct*, and sometimes obliterating it altogether, is the agitation produced by the mixture of air of different densities. Every observer knows the difference between good and bad definition, which passes through a variety of gradations from the greatest steadiness to the most violent "boiling." When the normal character of a spot under a certain altitude of the sun is well known, departures from this character become apparent; and if the observations have been well recorded and all known circumstances capable of affecting it registered, these departures stand out as *residual phenomena* awaiting explanation. It may be that the differences above alluded to are of this nature; but it is manifestly premature to discuss them until the observations have sufficiently accumulated to determine the normal character of the spot under every angle of illumination.

Herr Schmidt has announced that another spot, Alpetragius *d* [III A^{ν} 4], has manifested somewhat similar phenomena. I have carefully examined it with the Crossley Equatorial, and find it exactly as desribed by Schmidt, viz. a bright nebulous round spot of light, larger than *Linné*, with a small crater on the extreme S. edge of the bright spot. Lohrmann gives a bright elongated spot with a small hill on it; and B. & M. have drawn it distinctly as a crater.

The following is the letter addressed by Herr Schmidt to the Secretary of the Lunar Committee of the British Association for the Advancement of Science. The translation is by W. T. Lynn, Esq., of the Royal Observatory, Greenwich:—

Athens, 1868, June 5.

Honoured Sir,—I have lately given attention to a region of the moon which deserves in future a more accurate investigation. Although it furnishes by no means so significant a case as was afforded by *Linné*, it shows, however, something analogous, and leads to a better knowledge of certain spots of light which cannot in all cases be explained by mere phenomena of reflexion. The region in question is situated easterly near Alpetragius, the spot of light to which I direct your attention in 12° east longitude and 14° south latitude $= d$. Schröter has nothing about it. Lohrmann's (unedited) plate gives a *very large* spot of light, almost 2° in magnitude, and a very small hill inside it.

Mädler draws a crater of almost a mile [4·6 miles English] in diameter, and says in his 'Selenography' [Der Mond], page 304, line 22 from above, "In the furthest east shines also with a light of 8° the small crater *d*."

This crater *d* now no longer exists; but in its place is a round spot of light more than 2 miles [9·2 English] broad, extremely brilliant, which has quite the character of the light spot *Linné*, and of the few others of this kind which also are found upon the moon. The small neighbouring crater south of *d* which Mädler gives is still distinctly visible.

I have annexed three sketches—the first from Mädler, the second from Lohrmann, the third my own, on the scale of my chart.

Will you have the goodness to take an opportunity of informing the Lunar Committee of this notice, and request new observations with large instruments?

With the greatest esteem,

Yours most truly,

J. F. Julius Schmidt.

Bright spots on the moon are of two kinds, viz. those which are clearly and unmistakeably the slopes of mountains or the interiors of craters, and those which appear as round nebulous spots, apparently on the moon's surface, the true nature of which we are at present ignorant of. The brightness of the first class depends upon the following conditions, which determine the angle of illumination—1° and 2° the sun's altitude and azimuth at the spot, 3° and 4°, the angles which the slope and direction make with the lunar horizon and meridian. In the case of each particular spot certain values of the above-mentioned angles determine the maximum of illumination, and consequently the greatest brightness in the course of the lunar day. The bright spots of the second class do not conform to the before-mentioned conditions. They are apparently *horizontal*; but it has not yet been ascertained by observation whether they are in contact with the surface or otherwise. The three spots of this nature which have been most extensively observed are *Linné* [IE$^{\gamma\,1}$], *Posidonius* γ [IE$^{\epsilon\,3}$], and IV A$^{\alpha\,17}$ IV Aζ^{39}, and these present some very remarkable differences. Nearly throughout the whole course of the lunar day *Linné* appears as a white spot, varying slightly in brightness, and more so in size; generally it appears as nearly as possible of about the same size and brilliancy as *Posidonius* γ, sometimes slightly exceeding γ, and at other times a trifle less both in size and brightness. *Posidonius* γ is the highest part of a ridge on the *Mare Serenitatis*, having on its summit a minute pit. *Linné*, from the latest observations, is a small cone on a nearly level portion of the *Mare*. At and shortly after sunrise both have been distinctly seen as well-defined bright spots of the first class. At a very early period of the lunar day *Linné* exchanges the characteristics of the first

class for those of the second. *Posidonius* γ has not been observed so assiduously as *Linné*; it has, however, been found to retain the appearance of a mountain to a later period in the lunar day, when *Linné* has exhibited nothing but the ill-defined nebulous spot.

IV $A^{\alpha\,17}$ IV $A\zeta^{\,39}$, which differs from *Linné* and *Posidonius* γ, is a crater opened in the bottom of a depression which occurs in a mountain-chain on the east border of *Hipparchus*. Similarly to *Linné* and *Posidonius* γ, it is distinct and well defined shortly after sunrise, but, unlike them, it retains this appearance for a much longer period of the lunar day. Under a low solar altitude the eastern interior side of the depression in which the crater is situated is very bright, showing that for some time after sunrise it must be included in the first class of bright spots. On some occasions, when the sun has attained an altitude of about 20° above its horizon, it has presented a very similar appearance to that of *Linné* and *Posidonius* γ. On other occasions this appearance has not been observed until the sun has attained an altitude of nearly 40°. A bright streak has also been noticed extending from it towards the east, while the crater-form has been distinctly visible, with a solar altitude of nearly 30°. With solar altitudes above 48° to meridian altitude 85°, the appearance has been that of *two nebulous bright spots* of the second class.

While the three objects under high solar altitudes present precisely the same appearance, the lunar surface in each case differs materially :—*Linné*, a small isolated cone with crater opening (?) on a comparatively level surface; *Posidonius* γ, the highest point of a mountain-ridge, having a minute perforation; IV $A^{\alpha\,17}$ IV $A\zeta^{\,39}$, a somewhat large opening, with a small central one, in a depression also upon the summit of a mountain-range. It is clearly the province of observation to endeavour to ascertain in each case the circumstances which are intimately connected with the *first* appearance of the white spot. Apparently these spots appear to be *on the surface.* In the case of *Linné* the spot spreads around the cone or crater; in that of *Posidonius* γ it extends around the summit of the mountain, while in that of IV $A^{\alpha\,17}$ IV $A\zeta^{\,39}$ it covers the depression and included crater. Of the four conditions of brightness in the first class of bright spots, the sun's altitude appears to be connected with the first appearance of the white spot in the second class, but not regularly so, inasmuch as it appears earliest in *Linné* and latest in IV $A^{\alpha\,17}$ IV $A\zeta^{\,39}$. The discussion of observations is not sufficiently advanced to ascertain if the sun's azimuth at all affects these spots. The third and fourth conditions of the first class are clearly inapplicable to spots of the second class.

It has been suggested that the nature of the surface in these localities is such as to reflect the hazy light we see. We have in the three examples before us three different kinds of surfaces, as above mentioned. The greatest similarity of appearance of the white spot occurs in those cases in which the surfaces are most dissimilar, viz. a nearly level plain from which rises a small cone, and a mountain peak having a small orifice. While the surfaces are dissimilar, the feature in which the two objects closely resemble each other is the minute orifice which has been seen in both. We have consequently in two objects greatly differing from each other, two very close points of resemblance—the minute orifice seen with very low solar altitudes, and the comparatively large white spot seen under higher altitudes.

APPENDICES.

I.—BRITISH ASSOCIATION OUTLINE[a] MAP OF THE MOON, ZONE II., AREA IV A^{β}. (See Plate I.)

Preliminary Remarks.

THE principles upon which the map is constructed and the catalogue compiled, with the materials employed for these purposes, have been already mentioned in the Report presented at Nottingham in 1866. Instructions for observing the objects and correcting the detail will be found in the letterpress accompanying the areas IV A^{α} and IV A^{ζ}. In preparing IV A^{β} for engraving and printing, a few additional notices have become requisite. In addition to the symbols for indicating certain objects on the maps, inserted on p. 4 of letterpress to areas IV A^{α}, IV A^{ζ}, and Report Brit. Assoc. 1866, p. 240, three others may be found useful; so that the revised code of symbols will be as follows:—

·	Points of the first order.
×	Points of the second order.
-ȯ-	Bright spots.
o	Craters.
⊙	Rings.
◡	Depressions.
∧	Mountains.
∨	Valleys.
↓ (N.B. The arrow head is directed towards the lowest point.)	Mountain-slopes and valley-sides.
=	Clefts.
**	Very conspicuous objects.
*	Easy objects.
†	Difficult objects.
‡	Objects rarely visible.
B. & M.	Beer and Mädler.
L. S.	Lohrmann's Sections.
L. M.	Lohrmann's Map.
S. R.	Schmidt's Rills.
Eng. ft.	English feet.
——	Metres.

Of the photograms employed, De La Rue's, being so near the epoch of mean libration (Report Brit. Assoc. 1866, p. 215), is used for the determination of positions, while Rutherford's is the most suitable for the measurement of the extents and distances of objects. The elements of this photogram are as under:—

Epoch 1865, March 6.

For illumination:—Longitude of terminator $= 21^{\circ}\ 6'{\cdot}1$ E.
Inclination of terminator to meridian $= 1^{\circ}\ 6'{\cdot}6$
North pole enlightened.

[a] This map is not intended to be a perfect or complete Lunar Map, but only a guide to observers in obtaining data for the construction of a complete map.

For season:— $\odot - \Omega = 133^\circ\ 40'{\cdot}4$
Lunar summer in the northern hemisphere.

For position:—N. and S., Moon's latitude = 4 54·8 S.
E. and W., Moon past perigee 200 hours.
Moon less apogee 150 hours.

Objects are south and east of their mean places.

For size:—Moon's semidiameter 15′ 12″·9; mean semidiameter 15′ 32″·3.

A circle of one degree in diameter at the centre of the moon's disk is seen under an angle of 16″·277; at 5° of longitude W. or E. the degree is foreshortened in a radial direction, *i. e.* on the equator by 0″·061, the shortest diameter being 16″·216. At 10°, the N.W. angle of area IV A^β, or N.E. of III A^β, the foreshortening amounts to 0″·247, or nearly a quarter of a second, the shortest diameter being 16″·030.

The number of English feet subtending an angle of 1″·0 at the centre of the moon's disk *at mean distance* is 6116·7. This value is *increased* in receding from the centre in the proportion of the secants of the angular distances from the centre; consequently at the middle point of each area the value of 1″·0 is *greater* than at the centre of the moon's disk; for, by reason of the spherical surface of the moon, 1″·0 covers a greater portion of the surface at a point removed from the centre than at the centre. At the middle point of IV A^α, or 2° 30′ W. long., 2° 30′ S. lat., the angular distance from the centre = 3° 32′, which gives 6128·3 English feet for the value of 1″·0. At the middle point of IV A^β, or 7° 30′ W. long., 2° 30′ S. lat., the angular distance from the centre = 7° 54′, which gives 6175·3 English feet for the value of 1″·0. This is also the value for the middle point of IV A^ς. At the middle of IV A^η, or 7° 30′ W. long., 7° 30′ S. lat., the angular distance from the centre = 10° 35′, which gives 6222·7 English feet for the value of 1″·0.

While the values of 1″·0 vary in the proportion of the secants as we recede from the centre of the disk, the objects themselves remain of the same extent, and are seen *at mean libration*, either under the larger angle produced by the moon passing her perigean point, or under the smaller as she passes her apogee. Taking 6116·7 as a standard quantity, expressing the diameter of a circle seen under an angle of 1″·0 *at mean distance*, this quantity is seen at the centre of the disk, *mean libration*, moon in perigee, under an angle of 1″·059 ±, moon in apogee 0″·941. At perigee, *mean libration*, at the middle point of IV A^α, the foreshortening of an object of this extent is given by the following numbers:—Longest diameter 1″·059, shortest 1″·057. The difference is perfectly inappreciable; it is therefore presumable that we see *very nearly* the true forms of the objects on this area. At apogee, *mean libration*, the proportions are—0″·941 longest diameter, 0″·939 shortest. For the middle points of IV A^β and IV A^ς we have:—longest diameter 1″·059, shortest 1″·049, moon in perigee; and 0″·941 longest diameter, 0″·932 shortest, moon in apogee. At the middle point of IV A^η the foreshortening is greater, but still small:—moon in perigee, longest diameter 1″·059, shortest 1″·041; moon in apogee, longest diameter 0″·941, shortest 0″·925.

All the objects situated in areas IV A^α and IV A^β are so affected by libration that we see alternately more or less of their N. and S. sides. From the elements of Rutherford's photogram already given, it is easy to perceive that although the places are laid down on the areas for mean libration, the N. sides of the objects are presented in that photogram more directly to the eye; and this will to some extent affect the outline, inasmuch as the measures, more

particularly of the mountain-slopes, must necessarily include the *larger* angle under which they are seen on the photogram. It is only such objects as the orifices of craters, rings, and generally surface-markings, that are foreshortened to a greater degree as they are removed further from the eye by the effect of libration. The angle under which a mountain-slope, or any object which is elevated above the surface, is seen, is *increased* by libration as it is carried further from, and *decreases* as it is brought nearer to the eye; for if we take a mountain-range lying E. and W. on the equator, moon in node, we see the N. and S. slopes under the *smallest* angles. As the moon attains a greater N. latitude, the mountain-range is seen N. of its normal position, and we see more of its S. slope and lose its N. slope, the reverse taking place as the moon attains S. latitude. The degree of visibility of mountain-slopes or objects that are more or less elevated above the surface within the areas above mentioned is dependent more or less upon three conditions:—1°, the angle which the crest or longitudinal direction of an object makes with a lunar meridian; 2°, the angle which the slope makes with a vertical perpendicular to the moon's surface; and, 3°, the angle through which it is moved by the effect of libration. In each case there is a maximum effect, determined by the position and direction of the object. The visibility of objects within a zone of 1° 32′ 9″ N. or S. of the moon's equator is also affected by another circumstance, viz. the direction in which the sun's rays fall upon such objects at different seasons of the lunar year; for example, a mountain-range lying E. and W. on the moon's equator will have its N. slope illuminated while the sun is N. of the moon's equator, and its S. slope during the opposite season. The lunar seasons are easily found. When the sun's longitude, as seen from the moon (which does not at the utmost differ more than 8′ from the longitude as seen from the earth), is equal to the longitude of the moon's ascending node, the sun is vertical to the moon's equator, passing from S. to N. When the difference between the longitudes of the sun and node equals 90°, the N. pole is enlightened, and the season is summer in the northern hemisphere. When the longitudes of the sun and node differ 180°, it is the autumnal equinox in the northern hemisphere, and when the difference amounts to 270° it is winter, the S. pole being illuminated. These quantities may be thus expressed for the northern hemisphere:—

☉ − ☊ = 0° +	Sun in equator ascending.
☉ − ☊ = 90 +	Sun in tropic, N. pole illuminated.
☉ − ☊ = 180 −	Sun in equator descending.
☉ − ☊ = 270 −	Sun in tropic, S. pole illuminated.

In order to find the season, and consequently the illumination due to it of an object in the tropical zone 1° 32′ 9″ N. and S. of the moon's equator, nothing further is requisite than to find from the Nautical Almanac the longitudes of the sun and node: the quantity ☉ − ☊ will give the season as above.

If the sine of the angle ☉ − ☊ be multiplied into the sine of 1° 32′ 9″, the inclination of the moon's equator to the ecliptic, we obtain the sine of an angle which represents respectively the following quantities:—1°, the sun's declination as seen from the moon; 2°, the inclination of the equator of illumination to the moon's equator; and, 3°, the inclination of the terminator to the lunar meridian which it intersects.

From the above considerations it follows that in the *three areas* now issued, and also in the corresponding areas in Quadrants I., II., and III., we see lunar objects of very nearly their true forms, and that libration does not materially affect either their forms or magnitudes.

The visibility of objects *generally* is affected in a much greater degree by the morning and evening illuminations. Shortly after sunrise the slopes of mountains facing the W. are so illuminated that their detail may be well and satisfactorily made out. It is only a little before sunset that the E. slopes are similarly illuminated. Most of the *apparent* changes in the appearance of objects are due to these illuminations. It is, however, manifest that *low* and *flat* objects are less affected than *high* and *sloping* ones. We have already indicated (letterpress, areas IV A^a, IV A^ς, p. 7, and Report Brit. Assoc. 1866, p. 243) the mode of finding epochs of similar illumination; still the changes which some objects undergo as the sun rises above their horizons are so remarkable that it may in some measure assist the observer in endeavouring to refer these changes to their legitimate sources, if we give for the limits of each zone of 5° the sun's altitude for intervals of 12 hours during the period elapsing from sunrise to meridian passage, which will also be applicable to the decline from meridian passage to sunset. The epoch of sunrise at any particular spot with $\odot - \Omega = 0°$ or $180°$ is manifestly that at which the longitudes of the spot and terminator are equal; with $\odot - \Omega = 270°$ the sun is slightly above the horizon, and with $\odot - \Omega = 90°$ as slightly below in the southern hemisphere.

The longitude of the terminator may be found by the following formulæ:—Calling the longitude of terminator l_1, the moon's mean longitude l_0, the sun's true longitude $\odot$, west longitude on the moon's equator W, and E longitude E, then for the morning terminator we have

$$\text{W } l_1 = \odot - (270° + l_0),\ \text{E } l_1 = (270° + l_0) - \odot,$$

and for the evening terminator

$$\text{W } l_1 = \odot - (90° + l_0),\ \text{E } l_1 = (90° + l_0) - \odot.$$

TABLE OF SOLAR ALTITUDES AT THE MOON.

Equator.

Int.	Hour-angle.	Winter Solstice.	Equinoxes.	Summer Solstice.
h	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0	90 0 0	0 0 0	0 0 0	0 0 0
12	83 54 15	6 5 37	6 5 46	6 5 37
24	77 48 30	12 10 34	12 15 0	12 10 34
36	71 42 45	18 16 49	18 17 16	18 16 49
48	65 37 0	24 22 27	24 23 0	24 22 27
60	59 31 15	30 28 0	30 28 48	30 28 0
72	53 25 30	36 33 35	36 34 29	36 33 35
84	47 20 0	42 38 52	42 40 0	42 38 52
96	41 14 15	48 44 19	48 45 44	48 44 19
108	35 8 30	54 49 46	54 51 30	54 49 46
120	29 2 45	60 55 4	60 57 13	60 55 4
132	22 57 0	67 0 5	67 3 0	67 0 5
144	16 51 15	73 4 40	73 8 40	73 4 40
156	10 45 30	79 7 50	79 14 25	79 7 50
168	4 39 45	85 5 20	85 20 20	85 5 20
Mer.	0 0 0	88 27 51	90 0 0	88 27 51

TABLE OF SOLAR ALTITUDES AT THE MOON.

Latitude 5°.

Int.	Hour-angle.	Winter Solstice.	Equinoxes.	Summer Solstice.
h	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0	90 0 0	0 0 0	0 0 0	0 8 0
12	83 54 15	5 56 10	6 4 20	6 12 18
24	77 48 30	12 0 14	12 8 40	12 16 37
36	71 42 45	18 4 6	18 12 56	18 21 0
48	65 37 0	24 7 44	24 17 2	24 25 18
60	59 31 15	30 11 5	30 21 2	30 29 38
72	53 25 30	36 14 0	36 24 47	36 33 53
84	47 20 0	42 16 0	42 27 57	42 37 43
96	41 14 15	48 17 27	48 30 51	48 41 38
108	35 8 30	54 17 32	54 33 0	54 45 7
120	29 2 45	60 15 30	60 33 47	60 48 4
132	22 57 0	66 9 44	66 32 25	66 49 54
144	16 51 15	71 56 27	72 26 25	72 49 27
156	10 45 30	77 25 30	78 8 50	78 43 0
168	4 39 45	81 58 30	83 9 45	84 11 40
Mer.	0 0 0	83 27 51	85 0 0	86 32 9

TABLE OF SOLAR ALTITUDES AT THE MOON.

Latitude 10°.

Int.	Hour-angle.	Winter Solstice.	Equinoxes.	Summer Slstice.
h	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0	90 0 0	0 0 0	0 0 0	0 16 0
12	83 54 15	5 43 56	6 0 10	6 16 6
24	77 48 30	11 43 37	12 0 14	12 16 21
36	71 42 45	17 42 47	18 0 0	18 16 26
48	65 37 0	23 41 20	23 59 22	24 16 23
60	59 31 15	29 38 55	29 58 5	30 15 53
72	53 25 30	35 35 18	35 55 55	36 14 50
84	47 20 0	41 29 38	41 52 12	42 12 35
96	41 14 15	47 21 41	47 46 45	48 9 18
108	35 8 30	53 9 53	53 38 25	54 3 50
120	29 2 45	58 52 4	59 25 24	59 55 0
132	22 57 0	64 24 23	65 4 30	65 40 15
144	16 51 15	69 38 16	70 28 40	71 13 48
156	10 45 30	74 15 34	75 21 9	76 21 50
168	4 39 45	77 33 51	78 58 36	80 21 0
Mer.	0 0 0	78 27 51	80 0 0	81 32 9

The above Table has been computed from formulæ obligingly communicated by J. R. Hind, Esq., Superintendent of the Nautical Almanac. For the Altitudes,—

Nat sin of alt = nat sin of mer alt minus ver sin hour-angle × cos lat × cos dec and checked by

Ver sin zen dist = ver sin (lat ± dec) plus ver sin hour-angle × cos lat × cos dec.

One or two trials for obtaining the longitude of the terminator will be quite sufficient for finding the altitude for any given interval. In the case of the morning terminator, if its longitude is east of and differs from the longitude of the spot a few degrees only, the altitude will be found between interval 0 and 12 hours. It will, however, be best to compute a longitude of the terminator as near as may be to that of the spot, from the epoch of which intervals of 12 hours to meridian passage may very readily be found.

In addition to the period of similar phase, $59^{d}\ 1^{h}\ 28^{m}$, we have a still closer one of $442^{d}\ 23^{h}\ 0^{m}$, or 15 lunations. The numbers in the column on page xx of each month of the Nautical Almanac, headed "Days elapsed of the Julian Period," will greatly facilitate the application of this longer period. Changes arising from season and libration may, in consequence of comparing observations at epochs so distant, become more strikingly manifest.

Area IV A^{β}.

Introduction.

A few remarks upon the *classes* of objects found on this area and one or two other points may not be inappropriate; they are given under the following heads:—Points of the first order. Extent of surface. General features. Mountain-chains. Faults. Levels. Craters. Sequence of objects.

Points of the first Order.—The determination of one or two points of the first order in this area would be very advantageous for correcting the positions of objects in this and the neighbouring areas. For the mode of observing and computing, with an example, see Report Brit. Assoc. 1866, pp. 233 to 238. There are no isolated objects near the centre that would be suitable for this purpose; but IV A^{β} 19 is well situated for areas IV A^{α}, IV A^{ζ}, and IV A^{η}, and the crater IV A^{β} 3 for the N.W. part of area IV A^{β}.

Extent of Surface.—This is the same as area IV A^{α}, viz. 8877·925 square miles English, but, in consequence of foreshortening (see *ante*, p. 8), it does not appear to be so. The difference, however, is slight; for IV A^{α} occupies on the moon's equator ·0872 parts of the moon's radius considered as unity, and IV A^{β} ·0865 such parts.

General Features.—This area consists principally of an *elevated* district bordering upon the lower surface of the W. part of *Hipparchus*. It is not marked by any very bold features, except the W.N.W. border of *Hipparchus*, which presents apparently a steep slope towards the lower land. This slope may be well studied under the evening illumination, at about 19 or 20 days of the moon's age. With this exception, the surface is slightly irregular, dotted here and there with low mountains. The N.W. angle contains the central portion of what appears to be the remains of a large walled plain, but so altered by subsequent changes of the surface as to be scarcely recognizable. (See IV A^{β} 2, p. 16.) A comparatively undisturbed tract extends across the area from N.E. to S.W. *external* to the S.E. portion of the ancient ring surrounding the plain IV A^{β} 2, IV A^{γ} 3. This tract is situated entirely on the *high land* N.W. of *Hipparchus*, and separates two regions of considerable disturbance, viz. that marked by the cliffs which extend from the plain IV A^{β} 2, IV A^{γ} 3, to the ancient ring, and that characterized by the three

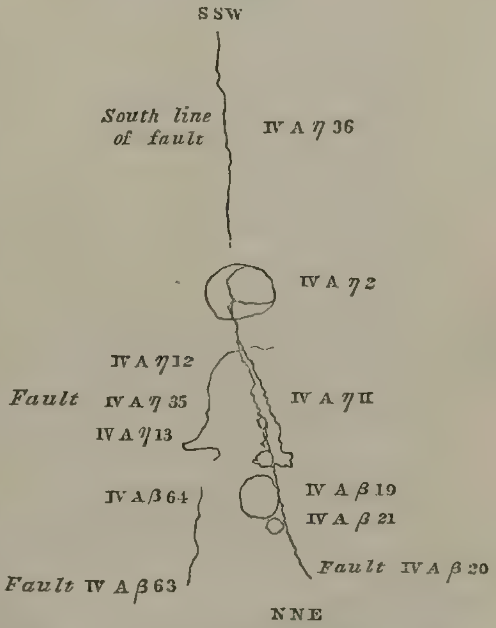
largest craters on the area, IV $A^{\beta 16}$, IV $A^{\beta 14}$, and IV $A^{\beta 19}$. It appears to have some relation to the ancient ring in its curvilinear direction.

Mountain-Chains.—This term is employed to designate long series of mountains, either in unbroken lines or, it may be, detached mountains occurring in lines. A portion of such a mountain-chain just crosses the S.W. angle of the area. It commences at the junction of the S. border of *Ptolemæus* with the W. border of *Alphonsus*, and rises into high peaks on the S.W. border of *Ptolemæus*: it forms the N.E. border of *Albategnius*, the ridges IV $A^{\zeta 67}$ and IV $A^{\zeta 82}$ (described as crater-rills by Schmidt, and so catalogued in area IV A^{ζ}) being the highest portions. From IV $A^{\zeta 67}$ it passes onward to the N.E. border of *Halley*, where the peak IV $A^{\zeta 29}$ rises to an altitude of 3543 English feet; it then passes along the cliff IV $A^{\eta 16}$, facing the lower surface of the S.W. part of *Hipparchus*, and is interrupted by a succession of valleys, but is resumed in the mountain IV $A^{\eta 13}$. At this part of the chain the hills are low compared with those on the borders of *Ptolemæus* and *Albategnius*. Skirting the border of IV $A^{\beta 93}$ and IV $A^{\beta 69}$, a plain intervenes between IV $A^{\beta 92}$ and IV $A^{\beta 70}$, from whence the chain is continued S. of the ring IV $A^{\beta 83}$. With various interruptions, it can be traced as far as *Sabine* and *Ritter*.

A short chain of cliffs occurs in the N. part of the area. The crests are generally transverse to the direction of the chain, which extends from IV $A^{\beta 3}$ to IV $A^{\beta 44}$.

Faults[a].—Several "faults" traverse this area—one, IV $A^{\eta 23}$ IV $A^{\beta 62}$, connected with the great Tychonic system, and three connected with the smaller system, of which IV $A^{\eta 2}$ appears to be the centre. The radiating character of the streaks from *Tycho* is well known. The "faults" connected with IV $A^{\eta 2}$ do not appear to be radiating, but to consist of three main "faults," one on the S.S.W., the others on the N. of the crater, both of which can be traced to a considerable distance. The annexed diagram (fig. 1) is intended to show the general direction of these "faults," IV $A^{\eta 36}$ and IV $A^{\eta 11}$, as emanating from IV $A^{\eta 2}$, also the fault IV $A^{\eta 35}$ IV $A^{\beta 63}$, diverging from IV $A^{\eta 11}$ in the direction of the mountain-ranges IV $A^{\eta 12}$, IV $A^{\eta 13}$, IV $A^{\beta 64}$, IV $A^{\beta 35}$, &c. The fault IV $A^{\eta 11}$ IV $A^{\beta 20}$ IV $A^{\alpha 72}$ is specially described in the letterpress to areas IV A^{α}, IV A^{ζ}, p. 19, and Report Brit. Assoc. 1866, p. 255.

Fig. 1.



Parallel with IV $A^{\eta 11}$, IV $A^{\beta 20}$, IV $A^{\alpha 72}$ in the N. part of the area are two of a minor character, IV $A^{\beta 51}$ and IV $A^{\beta 42}$, which apparently are not connected with any point of *outburst*. It is not improbable that these may be strictly contemporaneous with the main fault, and form portions of the same system. (See IV $A^{\beta 42}$, pp. 30, 31.)

[a] See note on p. 33.

In the W. part of the area is a very minor "fault," IV $A^{\beta\,89}$, nearly parallel with the main fault.

Levels.—There are only two levels on this area—the higher W. of *Hipparchus,* and the depressed W. floor of *Hipparchus.* These levels are separated by the "fault" IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$.

Craters.—The probable uncertainty which appertains to the earlier observations of the physical aspects of the moon's surface, by which it is difficult to arrive at any satisfactory conclusions relative to alleged physical change, renders it not only important but imperative that observations should now be conducted with such precision that no doubt may hereafter arise as to the *real* state of the object observed and recorded; it is accordingly intended that the description of each object recorded in the following pages shall be equivalent to a trustworthy and accurate observation; and as such observations can be obtained by means of photography, the epoch is that of the photogram employed, viz. 1865, March 6, unless otherwise expressed. Among the most prominent objects on the moon's surface are craters. It is in this class of objects that change has been suspected. To indicate the precision attainable with our present means, a list of the craters on area IV A^{β} is subjoined in the order of magnitude, so that, if any question should hereafter arise as to any one of them, this record, with the photogram from which it is compiled, will, it is hoped, be sufficient evidence of the state of each in the year 1865 on March 6; and to prevent any after-misapprehension as to whether these objects are actually craters, engravings are given of most of them, with the proportions of shadow to illuminated interior, at an epoch which may be approximately indicated by the longitude of terminator being equal to 21° E.

There are very few craters on IV A^{β} for so large an area—only fifteen, and most of these but small. Five are found near the fault IV $A^{\eta\,11}$, IV $A^{\beta\,20}$, IV $A^{\alpha\,72}$. Nearly all the others are isolated.

	"	"	m.
(1) IV $A^{\beta\,16}$	19·67	17·43	1·17
(2) IV $A^{\beta\,14}$	11·19		0·66
(3) IV $A^{\beta\,19}$	9·42	8·48	0·53
(4) IV $A^{\beta\,3}$	8·02	6·25	0·42
(5) IV $A^{\beta\,65}$	6·71	4·47	0·33
(6) IV $A^{\beta\,15}$	6·25	5·31	0·32
(7) IV $A^{\beta\,84}$	6·25	3·17	0·28
(8) IV $A^{\beta\,21}$	5·31	3·54	0·26
(9) IV $A^{\beta\,12}$	4·47		0·26
(10) IV $A^{\beta\,85}$	3·54	3·17	0·20
(11) IV $A^{\beta\,78}$	3·10		0·18
(12) IV $A^{\beta\,37}$	3·00		0·18
(13) IV $A^{\beta\,99}$	2·90?		0·17?
(14) IV $A^{\beta\,60}$	2·70		0·16
(15) IV $A^{\beta\,32}$	2·70		0·16

The first column of seconds (") are measures on the photogram of the longest diameters, the second of the shortest diameters. The last column contains the magnitudes, the diameter of *Dionysius* being regarded as unity. (See letterpress, areas IV A^{α}, IV A^{ζ}, p. 9, and Report Brit. Assoc. 1866, p. 245.)

Sequence of Objects.—The continuation of the subzones (see letterpress, areas IV A^{α}, IV A^{ζ}, pp. 5 and 6) in area IV A^{β} are as under:—

No. 1. Lat. 0° to 1° S.—1**, 2**, 3**, 29**, 49**, 52**, 4*, 10*, 11*, 12*, 13*, 53*, 40, 42, 45, 46, 50, 51, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 90, 91, 5‡, 6‡, 7‡, 8‡, 9‡.

No. 2. Lat. 0° to 2° S.—1**, 2**, 3**, 29**, 44**, 49**, 52**, 4*, 10*, 11*, 12*, 13*, 39*, 43*, 53*, 20, 32, 33, 40, 41, 42, 45, 46, 50, 51, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 67, 77, 78, 79, 90, 91, 99, 5‡, 6‡, 7‡, 8‡, 9‡.

No. 3. Lat. 1° to 3° S.—3**, 14**, 44**, 4*, 10*, 39*, 43*, 20, 26, 27, 30, 31, 32, 33, 40, 41, 42, 45, 46, 51, 55, 62, 63, 65, 66, 67, 73, 74, 77, 78, 79, 80, 89, 91, 98, 99.

No. 4. Lat. 2° to 4° S.—14**, 16**, 47**, 69*, 70*, 83*, 15, 18, 20, 22, 23, 25, 26, 27, 28, 30, 31, 34, 35, 36, 37, 42, 48, 51, 62, 63, 65, 66, 72, 73, 74, 75, 80, 84, 85, 86, 88, 89, 96, 97, 98, 76†.

No. 5. Lat. 3° to 5° S.—16**, 19**, 38**, 47**, 69*, 70*, 83*, 15, 17, 18, 20, 21, 22, 23, 24, 25, 26, 28, 31, 34, 35, 36, 37, 42, 48, 62, 63, 64, 68, 71, 72, 74, 75, 81, 82, 84, 85, 86, 87, 88, 89, 92, 93, 94, 95, 96, 97, 76†.

No. 6. Lat. 4° to 5° S.—16**, 19**, 38**, 69*, 70*, 17, 18, 20, 21, 24, 25, 35, 42, 48, 62, 63, 64, 68, 71, 72, 81, 82, 87, 88, 89, 92, 93, 94, 95, 96, 97.

Objects.

Points of the First Order. None.

Points of the Second Order, indicated thus × :—

	X[a].	Y[a].	S. lat.	W. long.
			° ′	° ′
IV $A^{\beta\,3}$	·02385	·16357	1 22	9 25
IV $A^{\beta\,12}$	·00000	·12187	0 0	7 0
IV $A^{\beta\,14}$	·05379	·12573	3 5	7 14
IV $A^{\beta\,16}$	·06976	·11149	4 0	6 25

N.B.—The Arabic numerals following the symbols of the areas, and designating the particular objects in this and other areas, are intended to be unalterable. See Report Brit. Assoc. 1865, p. 292.

☞ All measures for diameters of craters, unless otherwise expressed, are made at right angles to a line joining the N. edge of *Dionysius* and the S. edge of *Agrippa*. See Report, 1866, p. 245.

Mr. Slack has suggested that "crater-row" (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 23, † 19, and Brit. Assoc. Report, 1866, p. 259) should be regarded as a "test object" of the state of the earth's atmosphere, particularly with regard to definition; for example, if the craters, some of which are difficult, come out sharply and well defined, and can be seen distinctly and without tremor, the earth's atmosphere is in a good state for observation. When this is the case, and neighbouring objects are indistinct, hazy, and ill-defined, it may be inferred that such indistinctness is not occasioned by the state of the earth's atmosphere, but is dependent upon some other agency. In accordance with this suggestion, it is recommended that in the examination of the following objects the state of "crater-row" should be first ascertained.

While these sheets were passing through the press, Edward Crossley, Esq., of Halifax, kindly lent the Committee his 7·3-inch achromatic of 12 feet focal length, equatorially mounted. This instrument is now in working order at Walthamstow, and a systematic examination of the objects in the three areas, IV A^{α}, IV A^{β}, and IV A^{ζ}, commenced. The numeral of each object thus examined is followed by (x), thus ** 1 (x).

**1(x). A mountain-range, forming part of the northern boundary of the plain IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$. Length of crest 13″·425; do. from the highest point westward 10″·255, from the highest point eastward 3″·170; breadth of base at highest point 7″·645, at eastern end 6″·712, at western end 6″·239.

This boundary does not consist of a continuous range of mountains, but of detached or broken ranges. Commencing on the east, we have the mountain-arm IV $A^{\beta\,39}$ lying in the depression IV $A^{\beta\,41}$. The mountain-arm IV $A^{\beta\,39}$

[a] In the British Association Report, 1865, p. 295, will be found an explanation of the coordinates X and Y, with the formulæ for computing them when the position of the object on the moon's surface has been determined.

is separated from the short range IV $A^{\beta\,4}$ by a break or gorge, through which, under favourable circumstances, the sun has been seen clearly shining. IV $A^{\beta\,4}$ forms the E. rim of the crater IV $A^{\beta\,3}$, at the N. end of which another break occurs. Beyond this break is seen the mountain-range IV $A^{\beta\,1}$. The direction of IV $A^{\beta\,4}$ and IV $A^{\beta\,1}$ is nearly at right angles to that of IV $A^{\beta\,39}$. B. & M. describe and figure upon IV $A^{\beta\,1}$ *five* mountain-peaks, IV $A^{\beta\,5}$ to IV $A^{\beta\,9}$. They are inserted in the catalogue upon their authority; but, not having seen them, I have not yet inserted them upon the map. There are no traces of them upon Rutherford's photogram. B. & M. speak of them as being like a string of pearls. It is probable they may be detected a short time after sunrise. At the western end of IV $A^{\beta\,1}$ another break in the boundary occurs. This is succeeded by the range IV $A^{\beta\,13}$, IV $A^{\gamma\,1}$—the two ranges IV $A^{\beta\,1}$ IV $A^{\beta\,13}$, and IV $A^{\gamma\,1}$ forming a gentle curve, which is continued by the depression IV $A^{\gamma\,4}$. This depression completes the boundary—the plain IV $A^{\beta\,2}$, IV $A^{\gamma\,3}$ being quite open towards the S.W.

1864, Dec. 5, $6^h\,30^m$ to $7^h\,55^m$, this region was carefully observed with the Royal Society's achromatic of $4\frac{1}{4}$-in. aperture, power 230. The details recorded then mostly agree with the features as seen on the photogram. A few have not been recognized, of which the principal are as follows:—"The western part of the boundary was seen to consist of *three* detached rocks, of which the southern one was rather elongated. The mountain-arm IV $A^{\beta\,39}$ was observed to end in an irregular boss or club-shaped elevation, of less brightness than the mountain-arm."

**2(x). The E. part of the plain enclosed on the W. by the depression IV $A^{\gamma\,4}$, on the N. by the mountain-ranges IV $A^{\gamma\,1}$, IV $A^{\beta\,13}$, on the E. by IV $A^{\beta\,1}$ and IV $A^{\beta\,4}$, and on the S.E. by IV $A^{\beta\,39}$.

This plain is quite open towards the S.W., and has upon it the following objects:—The crater IV $A^{\beta\,3}$, which is the most conspicuous; a somewhat short elevated ridge, probably Lohrmann's 61 of his Sec. I., which I do not recognize on the photogram; and two minute hillocks between the ridge and crater. These hillocks are recorded in Obs. Bk. p. 164, No. 315, 1864, Dec. 5, 7.15 G.M.T. They are neither inserted in the map nor symbolized, as I do not find a second observation of them, and, not having made a sketch at the time, I am uncertain as to their position. I have the following note:—"With the exception of 60 and 61, Lohrmann gives the surface of this formation *smooth*. At present I do not see any other inequalities than the two minute hillocks." On Rutherford's photogram I find two objects to which the hillocks observed in 1864 may answer—IV $A^{\beta\,90}$, described as a "hillock on the plain, and IV $A^{\beta\,91}$, a shallow depression." It is probable I saw only the slope of the depression, which I regarded as that of a hillock.

This plain on Rutherford's photogram has greatly the appearance of a large ancient crater which has suffered from irruption and become nearly filled. If such has been the case, the wall has been broken through on the S.W., the open portion facing a somewhat smooth tract, agreeing in this respect with the numerous ruined craters (as they appear to be) on the borders of the *Maria*. The plain is interestingly situated with regard to *Godin* and *Agrippa*. The crater IV $A^{\beta\,3}$, as well as the cliffs between IV $A^{\beta\,3}$ and IV $A^{\beta\,14}$, are probably of more recent origin than the plain. The *depressions* IV $A^{\gamma\,4}$ and IV $A^{\beta\,41}$ at the extremities of the N.W. and S.E. ranges are remarkable. The occurrence of mountains standing in *shallow depressions* is not uncommon in some parts of the moon; it is a curious feature, and deserves careful consideration as well as observation.

A very remarkable and interesting feature is connected with this plain,

viz. a kind of "circumvallation" (consisting either of low mountains or, at some parts, of depressions) surrounds it, at an average distance from the centre of 35″·24, not very unlike the second rampart of *Rhæticus* (see letter-press, areas IV A^{α}, IV A^{ζ}, p. 12, and Brit. Assoc. Report, 1866, p. 248), or the cliffs surrounding IV $A^{\alpha\,4}$ (see *ibid.* pp. 13, 249). A portion of a similar circumvallation exists on the N.W. of *Agrippa*. The circumvallation surrounding IV $A^{\beta\,2}$ is best traced on the N. in the mountains W. and E. of *Godin*, including the S. border of that crater. The depression IV $A^{\beta\,49}$ and the mountain IV $A^{\beta\,14}$ are situated upon this line of circumvallation. Here it becomes obscure, but can be traced passing between IV $A^{\beta\,74}$ and IV $A^{\beta\,75}$, and continued in the mountain-chain extending from the junction of *Ptolemæus* and *Alphonsus* towards *Sabine* and *Ritter* (see *ante*, p. 13). From this mountain-chain the curve is continued to its junction with the S. of *Godin*.

The area enclosed by this "circumvallation" is about equal to that of the floor of *Ptolemæus*. Is this the remnant of a large walled plain which included a crater, nearly central, within it? Its position with regard to *Ptolemæus* is interesting, especially as the diverse groups on and near *Hipparchus* intervene. Its ancient character may be inferred from its being traversed by more than one "fault:"—first, a "ray from Tycho," which passes across its eastern segment; second, by the "fault" IV $A^{\beta\,42}$, which also crosses this segment. The "fault" IV $A^{\eta\,35}$ IV $A^{\beta\,63}$ grazes the E. edge of the ancient wall.

The following passage from the Rev. T. W. Webb's notice of Chacornac's 'Theory of Lunar Physics' is so much to the purpose that I quote it at length. "Among other characteristics of the primitive surface, we notice immense rings, whose crests alone project above the surrounding plain by some hundreds of yards—circular ramparts, the last visible vestiges of great buried craters; and these are cut through by considerable breaches, which permit us to follow the level of the maritime soil, where it penetrates their interiors, and to remark the absence of the slightest difference in surface or structure."—*Intellectual Observer*, No. xlvii. Dec. 1865, p. 373.

The surface of the area included within the line of circumvallation is in striking contrast with that of *Ptolemæus*. If it has ever been in the same state as that magnificent plain, the changes it has undergone must have been considerable. From a smooth level surface, surrounded by a rampart of mountains, the remains of which we are now only able to trace imperfectly, it must have passed into a state during which the central parts have been elevated, and the surface attained a degree of *subdued* irregularity very different from the surfaces of the great walled plains. While nearly every vestige of the characteristics of a walled plain has disappeared, the surface *included* by the circumvallation possesses a certain uniformity of aspect which gives an individuality to it, and which clearly separates it from the features external to it. It is singularly free from craters, two only of any magnitude being found upon it, viz. IV $A^{\beta\,3}$, and the crater S.S.E. of *Godin*, I $A^{\beta\,5}$. Should the conjecture be correct that we have here the remains of a large walled plain, the intermediate changes that it has undergone indicate it to have been very ancient, perhaps among the *most* ancient of lunar forms.

Hipparchus may be regarded as intermediate in character between this formation and *Ptolemæus*. We shall have to direct attention (see *post*, p. 37) to the probability that at some anterior epoch the depressed floor of *Hipparchus* and the higher land W. of it were at the same level, and that the whole of the district W. of *Hipparchus*, including the plain under consideration, has since been elevated. If so, from the appearance which this walled plain now presents, it is probable that the rampart was nearly filled *prior* to the general

elevation of the district of which it forms a part. This also points to its great antiquity, especially as the "fault" separating *Hipparchus* from the district appears to be comparatively recent.

**3(x). A crater on the E. part of the plain IV $A^{\beta\,2}$ IV $A^{\gamma\,1}$, position second order $\times 3$, ·0103 S.W. of photogram, M of B. & M., who mark it 7° of brightness. Lohrmann gives it 8°. It is 60 of his Section I. He describes it as small, and very deep. Its E. interior slope forms the W. slope of the mountain-range IV $A^{\beta\,4}$, which is the first of a series of short mountains connecting IV $A^{\beta\,3}$ with IV $A^{\beta\,14}$. It, as well as IV $A^{\beta\,14}$ and IV $A^{\beta\,19}$, is very deep, the shadow being still gibbous when the morning terminator has just passed *Copernicus*. The proportion of shadow to illuminated interior, when the longitude of the morning terminator=21° E., is as 1 to 1·833. See fig. 2. In the following engravings, representing the proportion of shadow to illuminated interior, the extent of shadow in all cases is equal to 1, but not upon the same scale, neither are the craters given on the same scale. IV $A^{\beta\,3}$ is the fourth crater in order upon area IV A^{β}. Diameter 6″·25; longest diameter on a line passing through IV $A^{\alpha\,40}$ 8″·02, mag. 0·42. It appears as a white spot under a high illumination.

Fig. 2.

1868, May 1ᵈ 8ʰ 0ᵐ G. M. T., I observed with the Crossley equatorial a white spot S. of IV $A^{\beta\,3}$, which was also seen with the Royal Astronomical Society's Sheepshanks telescope, No. 5, aperture 2·75 in., power 100, on May 30ᵈ 9ʰ 30ᵐ G. M. T., 1868.—[W. R. B.]

*4(x). A short mountain-range forming part of the E. boundary of the plain IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$. The N. end of this mountain-chain is λ of B. & M., whose measures give 6177 English feet, or 1883 French metres, for its altitude. Length of crest 8″·48. The breadth of base includes the depth of the crater IV $A^{\beta\,3}$, and is accordingly difficult to measure. Its E. slope appears to be very gradual.

‡5. The S.E. of B. & M.'s five peaks on IV $A^{\beta\,1}$ N. of IV $A^{\beta\,4}$. See *ante*, p. 16.

‡6. A peak between IV $A^{\beta\,5}$ and IV $A^{\beta\,7}$.

‡7. A peak between IV $A^{\beta\,6}$ and IV $A^{\beta\,8}$.

‡8. A peak between IV $A^{\beta\,7}$ and IV $A^{\beta\,9}$.

‡9. The N.W. of B. & M.'s five peaks on IV $A^{\beta\,1}$. See *ante*, p. 16.

*10(x). A short mountain-range parallel with IV $A^{\beta\,4}$. Length of crest 6″·25. It is situated near the point of intersection of two "faults," IV $A^{\gamma\,23}$ IV $A^{\beta\,62}$, and IV $A^{\beta\,42}$, the latter of which, although not so well marked as the "fault" IV $A^{\gamma\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$, can be easily traced as *parallel* with it on Rutherford's photogram.

It is difficult to determine whether Lohrmann really intended the S. extremity of his 63, Sec. I., to represent IV $A^{\beta\,10}$. If he did, then he has an *additional* range between 63 and 60, which is not apparent on the photogram. If he did not, then his range 63, Sec. I., is much longer than it ought to be. The cliffs between IV $A^{\beta\,3}$ and IV $A^{\beta\,14}$ are very indifferently shown by Lohrmann. The *boldest* are certainly in the neighbourhood of IV $A^{\beta\,3}$. His 59, Sec. I. (IV $A^{\beta\,80}$), which he has made the *boldest*, is certainly the *lowest*, as well as the last of the chain connecting IV $A^{\beta\,3}$ with IV $A^{\beta\,14}$. The direction of this chain is S.E.–N.W. See also IV $A^{\beta\,54}$, *post*, p. 32.

*11(x). A formation somewhat of the character of a *circular hill* with a depression of the nature of a crater nearly central. The E.N.E. boundary consists of a high mountain-range, IV $A^{\beta\,52}$, which, with IV $A^{\beta\,29}$, form a rampart parallel with the W.S.W. wall of Rhæticus. The interior of IV $A^{\beta\,11}$

dips on the E.N.E. from the W. edge of IV A$^{\beta 12}$ to the W.S.W. foot of IV A$^{\beta 52}$; the ridge IV A$^{\beta 61}$ crosses IV A$^{\beta 11}$ from S. to N.

Lohrmann describes and figures this formation as an enclosed plain, J of Sec. I. with central mountain, the surrounding mountains being 62 (IV A$^{\beta 52}$), 63 (IV A$^{\beta 54}$), and 64 (I A$^{\beta 28}$) of his Sec. I. He also speaks of two low rows of mountains between them. He says that in the midst of the *interior plain* a small *central mountain* is elevated. There is certainly nothing of the kind on Rutherford's photogram, March 6, 1865, neither *plain* nor *central mountain*. On the W. of IV A$^{\beta 11}$ is a hollow, IV A$^{\beta 49}$, communicating with a semicrater, neither of which are shown by Lohrmann. The boldness with which the formations IV A$^{\beta 11}$ and IV A$^{\beta 49}$ appear on the photogram is quite absent in B. & M.'s large map. IV A$^{\beta 11}$ is more distinct in the small map, 1837, but shown as a plain *without a central mountain.*

1867, Dec. 3, 10^{h}. Royal Astronomical Society's Sheepshanks telescope, No. 5, aperture 2·75, power 100. Identified IV A$^{\beta 29}$ and IV A$^{\beta 52}$, the E. mountainous boundary of the two formations IV A$^{\beta 11}$, IV A$^{\beta 49}$, answering to Lohrmann's 62, Sec. I., which are laid down correctly by him. Also IV A$^{\beta 57}$ and IV A$^{\beta 54}$, the W. boundary answering to his 63, Sec. I. The two low mountain-chains spoken of by Lohrmann I failed to identify, but I saw on the moon a mountain, between the two mountain-boundaries above specified, which is not the central mountain of J, Sec. I., but the mountain-ridge IV A$^{\beta 61}$ of IV A$^{\beta 11}$. It is probable that the mountain-ridge of IV A$^{\beta 11}$ is the E. of Lohrmann's two low ridges; and between this and his 63, Sec. I., is the depression IV A$^{\beta 49}$, not shown by him, and, instead of a *plain* and *central mountain* between the ridges IV A$^{\beta 61}$ and IV A$^{\beta 29}$ IV A$^{\beta 52}$, the S. part of the space is filled with the crater IV A$^{\beta 12}$, and the N. part *dips* to the N. angle of the formation IV A$^{\beta 11}$ I A$^{\beta 30}$.—[W. R. B.]

1868, May 1^{d} 8^{h} 45^{m} G. M. T.; Crossley equatorial 7·3 inches, power 122. Crater-row pretty well defined; IV A$^{\beta 11}$ very distinct, with the crater IV A$^{\beta 12}$ upon it. The surface of the hill is in the form of a tableland, IV A$^{\beta 29}$ and IV A$^{\beta 52}$ rising *higher* on the E., the W. slope of IV A$^{\beta 61}$ descending to the hollow.

It is very possible that Lohrmann regarded the tableland as an enclosed plain. The question now is whether the crater IV A$^{\beta 12}$ was regarded by him as a mountain. I do not see an exterior shadow on the E.; fig. 3 is too dark on the E. and N.E. The shading is not intended to indicate shadow, but the slope of the mountain on the N.E.—[W. R. B.]

As in the case of *Linné*, it may possibly be considered that both Lohrmann and B. & M. are in *error*. It does not appear that B. & M. mention the formation. The following is a translation by the Rev. T. W. Webb. of Lohrmann's notice (*Topographie der sichtbaren Mondoberfläche*, erste Abtheilung, p. 51):—

"(§ 47. I.) This landscape lies under 7° of W. longitude upon the equator, and is circularly encompassed by the high mountains 62, 63, and 64. Between these mountains, however, are also found two lower rows of mountains, going parallel with 63, that more closely encompasses I. In the middle of the inner plain a small central mountain raises itself."

*12(x). The central craterlet in IV A$^{\beta 11}$ 4″·47, mag. 0·26. The ninth in order upon area IV A$^{\beta}$, position second order × 12 on W. rim. This craterlet appears to be destitute of a *raised* wall, and is more of the character of a *dimple* at the summit of the *circular hill* composing IV A$^{\beta 11}$. With a morning terminator advanced a little beyond *Copernicus* the shadow is *crescentiform*; proportion to illuminated

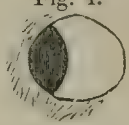
Fig. 3.

interior as 1 : 1·75 (see fig 3), breadth of shadow 1″·61 ±, illuminated interior 2″·89 ±.

*13(x). A mountain-range forming the N.W. portion of the boundary of the partly enclosed plain IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$; it is gently curved. Its W. portion is IV $A^{\gamma\,1}$. The central part is hollowed interiorly; length 13″·42; breadth of base, the E. part, 7″·18, the central part 6″·71, the W. part 6″·71.

**14(x). The northern of *three* very conspicuous craters, W. of *Hipparchus*, which are seen under every variety of illumination, the second in order on area IV A^{β}, 11″·19, mag. 0·66, E of B. & M. 7° of brightness, G of Lohrmann, Sec. I., 8° of brightness. Position second order × 14, ·0138 W.S.W. of photogram. It is N.W. of *Horrox*, and has a small shallow crater, IV $A^{\beta\,15}$, adjoining it on the S.E. It is situated very nearly on the border of the high land forming the W. border of *Hipparchus*. It appears from the photogram to be very deep. With a morning terminator advanced beyond *Copernicus*, long. 21° E., the interior shadow of the W. rim is still *gibbous*, the E. interior sloping upwards from it to the E. rim. At this stage of illumination the proportion of shadow to illuminated interior is as 1 : 1·667 (see fig. 4). Breadth of shadow 4″·20, of illuminated interior 6″·99.

Fig. 4.



15(x). A small shallow crater adjoining IV $A^{\beta\,14}$ on the S.E., the sixth in order upon area IV A^{β}. It is shown by B. & M. and Lohrmann. Longest diameter 6″·25, shortest 5″·31, mag. 0·32. It is situated on the very border of the high land W. of *Hipparchus*, and on the "fault" IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$.

**16(x). HORROX[a].—The largest crater on area IV A^{β}. It is marked *b* on B & M.'s map, 232 on Lohrmann's, and F on Lohrmann's Sec. I. Position second order × 16, ·0204 W. of IV $A^{\beta\,22}$ on photogram. Longest diameter E. by N.–W. by S. (nearly) 19″·67, shortest N. by W.–S. by E. 17″·43, mag. 1·17. B. & M. record a brightness of 3° for the interior, and 5° for the border, when seen under favourable circumstances. Lohrmann's value is from 4° to 5°. Its form consists of a semiellipse on the east side, and two nearly rectilineal walls on the W., which are inclined to each other at an obtuse angle. It has a low central hill, IV $A^{\beta\,22}$, but not a very level floor, on which are two hillocks, IV $A^{\beta\,23}$ and IV $A^{\beta\,24}$. The interior is probably bowl-shaped. The E. interior slope rises from this floor, and with a morning terminator advanced beyond *Copernicus* is brightly illuminated; the E. boundary of the shadow of the W. border is nearly rectilinear. Proportion at this stage:—shadow to illuminated portion as 1 : 1·509 (see fig. 5); breadth of shadow 7″·84, of illuminated interior 11″·83. There are two ridges on the interior W. slope. *Horrox* appears as an isolated crater on the lower level of the N.W. part of *Hipparchus*. The space between the N.W. wall of *Horrox* and the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$ is mentioned by Lohrmann as a narrow valley (*Topographie der sichtbaren Mondoberfläche*, sec. i. p. 50). This appears to be the mouth of the valley IV $A^{\beta\,31}$ IV $A^{\alpha\,77}$, in which is the depression IV $A^{\beta\,28}$.

Fig. 5.

17. HIPPARCHUS[b].—Lohrmann's Map 233. The north-western part. This formation is described in the letterpress to areas IV A^{α}, IV A^{ζ}, pp. 12, 13, and in the Report of the Brit. Assoc. 1866, pp. 248, 249. As it is only seen

[a] Named in commemoration of Mr. Horrox, who computed and observed the transit of Venus in the year 1639.

[b] Named by Riccioli in commemoration of Hipparchus, who compiled the *first* catalogue of the fixed stars in the second century before our era.

to advantage shortly after the time of sunrise and a little before sunset, and is lost to view as a separate formation under a high illumination, to mark more clearly the territory of which it forms the western part, and which is of a much more individual character than *Hipparchus*, it is proposed to group the various objects which this territory contains under the general designation of "*Terra Astronomica*," as suitable for the district, a portion of which is commemorated by the name of the greatest astronomer of his time, and which is surrounded by walled plains and craters, named in commemoration of celebrated ancient and modern astronomers. The term is also suitable as a companion to the region in the south, which has been named "*Terra Photographica*," to commemorate the labours of De La Rue in Celestial Photography. See Report, 1865, p. 305.

Terra Astronomica.

An extensive formation situated on the following areas:—

IV A$^{\eta}$	IV Aζ	III Aζ
IV A$^{\beta}$	IV A$^{\alpha}$	III A$^{\alpha}$

Fig. 6.

It is N. of *Albategnius*, N.W. of *Ptolemæus*, and extends from these walled plains as far N. as the equator.

This interesting region may be described under the heads of "Boundaries" and "Interior Formations."

Boundaries. — Commencing at the angle formed by the junction of the walls of *Albategnius* and *Ptolemæus*, at which point we find the crater IV Aζ^{12}, and proceeding W.N.W. as far as the small crater IV Aζ^{33}, along the crest of a range of hills on which IV Aζ^{36} is situated upon the highest point, we traverse the common boundary of *Terra Astronomica* and *Albategnius*. At the point IV Aζ^{33} we leave *Albategnius*, and proceeding along IV Aζ^{26}, we arrive at the mountain IV Aζ^{29}, on the E. of *Halley*, which is a fine crater just exterior to the S.W. border of *Hipparchus*. From the N. angle of *Halley*, the cliff IV A$^{\eta\ 16}$, terminating the high land from IV A$^{\mu\ 3}$ to IV A$^{\eta\ 6}$ facing *Hipparchus* and forming the continuation of its S.W. border, proceeds in nearly the same direction as IV Aζ^{26} towards the depression IV A$^{\eta\ 6}$. This cliff terminates with the peak IV A$^{\eta\ 19}$, *a* of B. & M. and 29 of Sec. I. of Lohrmann; but the range of mountains of which it forms a part preserves its nearly rectilineal direction from the junction of the S.W. border of *Ptolemæus* with the N.W. border of *Alphonsus* to *Ritter* and *Sabine* (see *ante*, p. 13). It is between this cliff and IV A$^{\beta\ 19}$ that we meet with certain valleys which break through the wall of *Hipparchus*, viz. IV A$^{\eta\ 18}$ and IV A$^{\eta\ 6}$. N.W. of IV A$^{\eta\ 6}$ is the peak IV A$^{\eta\ 20}$, 30 Sec. I. of Lohrmann, immediately adjoining which on the N.W. is the long narrow valley IV A$^{\eta\ 11}$, described by Julius Schmidt as a crater-rill (cleft) in his Catalogue of Rills, No. 362. The openings of these valleys to-

wards *Hipparchus* impart a somewhat curvilinear form to the boundary hereabout. From the N.E. end of IV A$^{\eta\,11}$, which lies in the depression IV A$^{\eta\,31}$, as far as the E. edge of the crater IV A$^{\beta\,14}$, the boundary is nearly rectilinear and nearly coincident with the "fault" IV A$^{\eta\,11}$, IV A$^{\beta\,20}$, IV A$^{\alpha\,72}$, which, probably originating in the crater IV A$^{\eta\,2}$, has either elevated the surface on the W. or depressed the surface of the W. portion of *Hipparchus*, so that it is considerably below the high land; between IV A$^{\beta\,19}$ and IV A$^{\beta\,14}$ this high land rises into the peaks IV A$^{\beta\,33}$ and IV A$^{\beta\,47}$. At the crater IV A$^{\beta\,14}$ this portion of the boundary forms a very obtuse angle with the valley IV A$^{\beta\,31}$ IV A$^{\alpha\,77}$, which extends as far as the N. end of IV A$^{\alpha\,10}$. Here the boundary becomes indistinct. Beer and Mädler, who do not give the "fault" nor the valley, show the boundary as turning E. at IV A$^{\beta\,14}$, passing the cliff or mountain IV A$^{\alpha\,14}$ at the S. end of IV A$^{\alpha\,10}$, and passing along the depressions IV A$^{\alpha\,12}$ and IV A$^{\alpha\,13}$ (neither of which they show), proceeding to the crater IV A$^{\alpha\,7}$, and further continued parallel with the W. mountainous border (IV A$^{\zeta\,47}$) of IV A$^{\zeta\,24}$, Lohrmann's W, Sec. I., through the crater IV A$^{\zeta\,6}$ to or near the small crater IV A$^{\zeta\,33}$. The dotted line shows the approximate direction of the N. and S.E. boundaries as given by B. & M. and Lohrmann. Lohrmann in Sec. I. indicates, although not very distinctly, the "fault" and valley.

The N. and S.E. boundaries of *Hipparchus*, as laid down by B. & M. and Lohrmann, are by no means so distinct on the photogram as shown on the map and section. The *natural* boundary of the large formation *Terra Astronomica* appears to be continued from the junction of the valley IV A$^{\beta\,31}$ IV A$^{\alpha\,77}$ with the "fault" IV A$^{\eta\,11}$ IV A$^{\beta\,20}$ IV A$^{\alpha\,72}$, along the higher land between the valley and *Rhæticus*, through the S.E. mountainous border of *Rhæticus* to the N.E. angle of *Rhæticus* N. of the equator; it then trends E.S.E. along the S.W. border of the Sinus Medii to the N. border of the little plain N.E. of *Reaumur*. From thence it trends E. to the mass of high land on the N.W. border of Lohrmann's U, Sec. I., III A$^{\alpha\,1}$, the W. border of which carries it on to the circular "tableland" III A$^{\alpha\,9}$, N. of *Herschel*; the W. edges of this "tableland" and *Herschel* bring us to the N. of *Ptolemæus*, the N.W. border of this walled plain being common to *Ptolemæus* and *Terra Astronomica*.

Within the boundary now traced out, a more or less individualized formation will be found; and as no part has received a distinct name except the S.W. ("*Hipparchus*"), the whole may not inappropriately be termed "*Terra Astronomica*."

Interior Formations.—These may be characterized as Cliffs, Lines of Upheaval[a], Mountains, Plains, Depressions, Faults, and Craters.

Cliffs.—Two well-marked lines of cliffs cross the *Terra Astronomica* in divergent directions from the N.W. angle of *Rhæticus*. They are both distinct on the photogram.

The W. line of cliffs from the N.W. angle of *Rhæticus*, along its W. border, passes W. of IV A$^{\alpha\,10}$, through the W. part of *Hipparchus*, past the prominent cliff IV A$^{\zeta\,38}$ (where the curved chain IV A$^{\zeta\,58}$ branches from it) towards the space between IV A$^{\zeta\,27}$ and IV A$^{\zeta\,28}$, through the middle of IV A$^{\zeta\,25}$, to IV A$^{\zeta\,36}$, on the N.E. border of *Albategnius*. Leaving *Hipparchus*, this line of cliffs crosses the N.E. part of *Albategnius*, and terminates on the E. border of the crater IV A$^{\lambda\,6}$, on the E. of *Albategnius*. The faces of these cliffs are of a

[a] The lines of upheaval and depression upon areas IV A$^{\alpha}$, IV A$^{\zeta}$ are tabulated and described in the letterpress to those areas, pp. 33 to 39, and Brit. Assoc. Report, 1866, pp. 269 to 275.

gently sloping character, are directed towards W. by N., and in "Full Moon" the line is seen as a "Ray" from "Tycho." See letterpress, areas IV A^{α}, IV $A\varsigma$, pp. 31 and 32, and Report Brit. Assoc. 1866, pp. 267, 268. Neither B. & M. nor Lohrmann give this line of cliffs.

The N.E. line of cliffs (direction N.W.–S.E.) is a portion of a somewhat interrupted line which extends from the E. border of *Ptolemæus* to a mass of high land E. of *Agrippa*. In crossing the *Terra Astronomica* from the W. border of Herschel, it is slightly curved, the convexity being towards the S.W. and the faces of the cliffs towards the N.E. The altitude may be about equal to the lower portions of the mountainous border of *Ptolemæus*. It is very imperfectly represented on B. & M.'s and Lohrmann's maps, but it may be traced on Lohrmann's Sec. I., although the character of a range of cliffs is not given. Passing along the range from *Herschel* towards the N.W., we find it first cut through by the valley III $A^{\alpha\,2}$ III $A\varsigma^{2}$; and parallel with this valley on the N.W. is a short mountain-arm, which springs from the line of cliffs, and probably forms the highest part of the boundary of the valley on the N.W. It is next cut by a "fault," III $A^{\alpha\,8}$ and III $A\varsigma^{15}$, which will be hereafter described. Just W. of this "fault" is the crater IV $A^{\alpha\,6}$ III $A^{\alpha\,10}$, which is situated on the line of cliffs and appears to be its culminating point. From thence the line is continued to the S. edge of *Reaumur*, and merges into the S.W. and W. border of *Reaumur*, of which IV $A^{\alpha\,5}$ is the highest point. From the W. border of *Reaumur* the crater IV $A^{\alpha\,4}$ appears to connect it with the short mountain-chain IV $A^{\alpha\,15}$, which joins the S.E. border of *Rhæticus*. This line of cliffs is more strongly marked on the photogram than the boundary of *Hipparchus*, as shown by B. & M. and Lohrmann.

Mountains.—The isolated mountains on this formation are but few; the most important are IV $A\varsigma^{30}$ and IV $A\varsigma^{31}$ on the subformation IV $A\varsigma^{25}$. The remainder are either cliffs or mountain-borders of depressions and plains.

Plains.—Three distinct plains may be specified as occurring on this formation—Lohrmann's W, Sec. I., *Reaumur*, and the small plain N.E. of it. They are all surrounded by mountain-borders. To these may be added the S.W. part of *Hipparchus*, W. of the westerly line of cliffs, which is the most level part of the formation.

Depressions.—The most remarkable and important of these is the valley III $A^{\alpha\,2}$ III $A\varsigma^{2}$, N.W. of *Herschel*, crossing the N.E. line of cliffs; and next is IV $A^{\alpha\,10}$, which is fully described under the symbols IV $A^{\alpha\,10}$, IV $A^{\alpha\,42}$ in letterpress to areas IV A^{α}, IV $A\varsigma$, pp. 14 & 17, and Report, Brit. Assoc. 1866, pp. 250 and 253. IV $A^{\alpha\,12}$, IV $A^{\alpha\,13}$ may also be included. In addition a large depression, IV $A\varsigma^{122}$, is found between two ridges, which extend from IV $A^{\alpha\,7}$ and IV $A^{\alpha\,28}$ to IV $A\varsigma^{86}$. It is well shown in De La Rue's photogram of Feb. 22, 1858, and another, IV $A\varsigma^{119}$, between the crater IV $A\varsigma^{1}$ and the mountains IV $A\varsigma^{37}$ and IV $A\varsigma^{61}$.

The most remarkable subformation on *Terra Astronomica* is IV $A\varsigma^{25}$, a careful description of which will be found under its symbol in letterpress to areas IV A^{α}, IV $A\varsigma$, pp. 24 and 25, and Report of British Association, 1866, p. 261.

Faults.—In addition to the "fault" on the W.N.W. boundary, a remarkable one, III $A^{\alpha\,8}$ III $A\varsigma^{15}$, extends from the N.W. border of *Ptolemæus* to the E. border of *Reaumur*. It crosses the space between *Ptolemæus* and the plain IV $A^{\alpha\,9}$ III $A^{\alpha\,7}$ III $A\varsigma^{14}$ IV $A\varsigma^{24}$ (W, Lohr. Sec. I.), grazes the S.W. extremity of the valley III $A^{\alpha\,2}$ III $A\varsigma^{2}$, N.W. of *Herschel*, and then traverses the plain, just grazing the E. edge of the crater III $A^{\alpha\,10}$, where it cuts the

line of cliffs III Aζ 13, III A^{α} 5, IV A^{α} 8. From thence the "fault" extends to the E. edge of *Reaumur*; its face is towards the E.

This "fault" is not unlike, but lower in altitude than, *Straight Wall*. It is not so prominent an object as *Straight Wall*, which, occurring throughout its entire length on a plain, is very easily seen, whereas the "fault" now under notice traverses a variety of surface, and is moreover surrounded by striking and conspicuous objects, among which it may readily be overlooked. It is nevertheless an interesting object.

Craters.—The following is an enumeration of the craters and craterlets at present recorded as existing on or within the boundaries of the *Terra Astronomica*, as now described.

Area IV Aζ.

1.	IV Aζ 12 ..	In the S.E. angle	B. & M. G.	L.	Ph.
2.	IV Aζ 5 ..	On S.E. portion S.W. of IV Aζ 1	....	L.	Ph.
3.	IV Aζ 95 ..	,, ,, ,, S. of IV Aζ 4.			
4.	IV Aζ 4 ..	,, ,, ,, S.W. of IV Aζ 1 ..	B. & M.	L.	Ph.
5.	IV Aζ 1 ..	,, ,, ,, ...	B. & M.	L(x).	Ph.
6.	IV Aζ 7 ..	,, ,, ,, N. of IV Aζ 1 ..	B. & M. K.	L.	Ph.
7.	IV Aζ 21 ..	,, ,, ,, E. of IV Aζ 7 ..	B. & M.		
8.	IV Aζ 22 .	,, ,, ,, W. of IV Aζ 7 ..	B. & M.		
		These seven craters form a fine and conspicuous group.			
9.	IV Aζ 13 ...	Between IV Aζ 1 and Ptolemæus..	B. & M.		
10.	IV Aζ 14 ..	,, ,, ,, ,,	B. & M.		
11.	IV Aζ 15 ..	,, ,, ,, ,,	B. & M.		
12.	IV Aζ 18 ..	,, ,, ,, ,,	B. & M.		
13.	IV Aζ 19 ..	,, ,, ,, ,,	B. & M.		
		These five craters form a "row" connecting IV Aζ 1 with the N.W. border of Ptolemæus. B. & M. give *six*. See letter-press, areas IV A^{α}, IV Aζ, p. 23. IV Aζ 19. The "crater-row" appears as a lucid streak on the photogram, but is easily resolvable in the telescope.			
14.	IV Aζ 121 ..	N. of IV Aζ 13.			
15.	IV Aζ 115 ..	N. of IV Aζ 14.			
16.	IV Aζ 49 ..	On the S. end of IV Aζ 47.			
17.	IV Aζ 39 ..	A crater[a] W. of the mountain-arm, IV Aζ 47.			
18.	IV Aζ 112 ..	S.S.W. of IV Aζ 39.			
19.	IV Aζ 113 ..	S.E. of IV Aζ 112.			

[a] This crater is one of a class which has been but recently suspected to exist on the moon, and of which the crater *Linné* in the *Mare Serenitatis* was probably the first observed. The principal characteristic of this class of objects consists in the occasional obscuration of the crater-form, nothing being seen but a white spot, which is very often indistinct and undefined in its outline. In the case of *Linné* this white spot has been observed to present itself rather suddenly. See Astronomical Register, No. 60, Dec. 1867, p. 254. The observations of IV Aζ 39 will be found in the same work, No. 62, Feb. 1868, p. 43, and also in the Proceedings of the Manchester Literary and Philosophical Society, vol. vii. p. 73.

Area IV Aς (*continued*).

20.	IV Aς^{103} ..	E. of IV Aς^{112} and IV Aς^{113}.			
21.	IV Aς^{6} ..	A conspicuous crater W. of IV Aς^{1}.	B & M. i.	L.35	Ph.
22.	IV Aς^{42} ..	Between the N.E. border of Albategnius and IV Aς^{4}. On the W. line of cliffs	....	....	Ph.
23.	IV Aς^{43} ..	Between IV Aς^{42} and IV Aς^{4} ..	....	....	Ph.
24.	IV Aς^{93} ..	N.W. of IV Aς^{43}.			
25.	IV Aς^{94} ..	N.W. of IV Aς^{93}.			
26.	IV Aς^{91} ..	N.W. of IV Aς^{94}.			
27.	IV Aς^{90} ..	S. of IV Aς^{91}.			
28.	IV Aς^{92} ..	On W. line of cliffs S. of IV Aς^{6}.			
29.	IV Aς^{41} ..	W.S.W. of IV Aς^{6}	....	....	Ph.
30.	IV Aς^{45} ..	N.W. of IV Aς^{6}	....	....	Ph.
31.	IV Aς^{46} ..	N.N.W. of IV Aς^{45}............	....	....	Ph.
32.	IV Aς^{100} ..	In the line of ancient wall of IV Aς^{58}			
33.	IV Aς^{62} ..	N. of IV Aς^{29}.			
34.	IV Aς^{63} ..	N.E. of IV Aς^{62}.			
35.	IV Aς^{64} ..	N.E. of IV Aς^{63}.			

Area III A$^{\alpha}$.

36.	III A$^{\alpha\,10}$ ..	On N.E. line of cliffs	B. & M. A.	L.92	Ph.

Area IV A$^{\alpha}$.

37.	IV A$^{\alpha\,4}$ ..	Central in the depressed tract IV A$^{\alpha\,11}$....................	B. & M. H.	L.	Ph.
38.	IV A$^{\alpha\,86}$ ..	N. of IV A$^{\alpha\,4}$.			
39.	IV A$^{\alpha\,90}$ ..	W.N.W. of Reaumur.			
40.	IV A$^{\alpha\,89}$ ..	On S.S.W. border of Reaumur.			
41.	IV A$^{\alpha\,57}$ ..	On the S. border of Reaumur ..	....	....	Ph.
42.	IV A$^{\alpha\,6}$ ..	The W. part of the crater III A$^{\alpha\,10}$	B. & M. A.	L.92	Ph.
43.	IV A$^{\alpha\,7}$ ..	Between Horrox and III A$^{\alpha\,10}$ ..	B. & M. F.	L.	Ph.
44.	IV A$^{\alpha\,17}$ ..	The N. part of the crater IV Aς^{39}	....	....	Ph.
45.	IV A$^{\alpha\,22}$ ..	S.E. of IV A$^{\alpha\,7}$	....	....	Ph.
46.	IV A$^{\alpha\,23}$ ..	S.E. of IV A$^{\alpha\,22}$	....	....	Ph.
47.	IV A$^{\alpha\,24}$ ..	N.N.E. of IV A$^{\alpha\,7}$	....	....	Ph.
48.	IV A$^{\alpha\,26}$ ..	N.W. of IV A$^{\alpha\,24}$...............	B. & M.	L.	Ph.
49.	IV A$^{\alpha\,93}$ ..	E. of IV A$^{\alpha\,24}$.			
50.	IV A$^{\alpha\,18}$ ..	S.E. of Horrox	....	....	Ph.
51.	IV A$^{\alpha\,78}$ ..	In the angle between IV A$^{\alpha\,38}$ and IV A$^{\alpha\,48}$	....	....	Ph.
52.	IV A$^{\alpha\,44}$ ..	The southern craterlet on [the ridge IV A$^{\alpha\,43}$	....	....	Ph.
53.	IV A$^{\alpha\,45}$ ..	The middle craterlet on IV A$^{\alpha\,43}$..	....	....	Ph.
54.	IV A$^{\alpha\,46}$ ..	The northern craterlet on IV A$^{\alpha\,43}$	....	....	Ph.
55.	IV A$^{\alpha\,60}$ ..	At the N. end of IV A$^{\alpha\,58}$	....	....	Ph.
56.	IV A$^{\alpha\,97}$ ..	The southern craterlet in IV A$^{\alpha\,58}$	....	....	Ph.
57.	IV A$^{\alpha\,98}$ ..	The northern craterlet in IV A$^{\alpha\,58}$	....	....	Ph.

Area IV A^{β}.

58.	IV A^{β} 16 . .	Horrox.—The most conspicuous crater on *Terra Astronomica*, mag. = 1·17	B. & M. *b.*	L.F.	Ph.

The initials B. & M. signify that the crater is to be found in Beer and Mädler's Map, L. in Lohrmann's Sections, and Ph. on De La Rue's and Rutherford's Photograms.

18(x). A depression W. of *Horrox* and the W. border of *Hipparchus*, nearly midway between IV A^{β} 14 and IV A^{β} 19. It is very irregular in form, and filled with a mountain-mass which gradually ascends from the W. and N. to the very border of *Hipparchus*. This mountain-mass rises from the W. foot of IV A^{β} 18, and culminates in the peak IV A^{β} 38, which is the highest point in the W. border of *Hipparchus*. It has upon it a *white* spot, IV A^{β} 37, just where the rise commences towards *Hipparchus*. This spot is probably the small crater given by B. & M. and Lohrmann[a]. It presents an appearance analogous to that of *Linné*, both on the photogram and as seen in 1867, and should be watched attentively from time to time. It spreads gradually from a *bright centre*, and degrades in brilliancy as the valley at the foot of the mountain-mass is approached. The brightness of IV A^{β} 37 scarcely equals that of *Linné* on Rutherford's photogram, 1865, March 6.

A mountain-crest crosses IV A^{β} 18 from N.W. to S.E., the N.E. side being filled with the mountain-mass IV A^{β} 47, which also culminates on the border of *Hipparchus*. Between IV A^{β} 38 and IV A^{β} 47 is an inlet, IV A^{β} 48, in the mountain-border facing the plain W. of *Horrox*. IV A^{β} 18 appears as a somewhat large bright spot in full moon, but is not a very conspicuous object at other times.

**19(x). The middle of three very conspicuous craters W. of *Hipparchus* (see IV A^{β} 14). It is G of B. & M., who record it as of 7° of brightness, and E of Lohrmann's Sec. I. It is the third crater in order upon area IV A^{β}. Its longest diameter measures 9″·42, and shortest 8″·48, mag. 0·53. This crater is very deep, and has a small crater, IV A^{β} 21, adjoining it on the N.E. It is situated on the sloping edge of the high land W. of *Hipparchus*, and in the angle formed by the intersection of the fault IV A^{η} 11 IV A^{β} 20 IV A^{α} 72 with the fault IV A^{η} 23 IV A^{β} 62 (see letterpress to areas IV A^{α}, IV A^{ζ}, pp. 19, 20, and Report Brit. Assoc. 1866, pp. 255, 256). With a morning terminator advanced beyond *Copernicus*, the interior shadow of the W. rim is decidedly gibbous (see fig. 7), the E. interior sloping upwards from it to the E. rim. Breadth of shadow at this stage of illumination 3″·78, of illuminated interior 4″·71. The proportion of shadow to illuminated interior of the E. slope is as 1 : 1·25. This is not so small as the proportion of shadow to the bright interior of the crater IV A^{β} 14; and this, with the shadow of IV A^{β} 19 being more gibbous than that of IV A^{β} 14, indicates that IV A^{β} 19 is the deeper crater.

Fig. 7.

The form of IV A^{β} 19 departs very considerably from that of a circle; the

[a] 1868, May 1d 9h 45m G.M.T., it was seen with the Crossley equatorial, 7·3-in. aperture, most unmistakeably as a crater with gibbous interior shadow of about ·33 of the diameter. On May 2d 7h 25m G.M.T., it exhibited some approximation to the class of "light-centres." See Brit. Assoc. Report, 1866, p. 218.

S.W. edge is nearly but not quite straight. It is slightly curved, with the convexity towards the *centre* of the crater. This edge measures 5″·78. The curvature of the remainder of the rim is much greater, and the convexity outwards.

20(x). Part of the "fault" from IV $A^{\eta\,2}$ to *Rhæticus*. This fault is fully described under IV $A^{\alpha\,72}$ in letterpress to areas IV A^{α}, IV A^{ζ}, pp. 19, 20, and Report Brit. Assoc. 1866, pp. 255, 256.

21(x). A craterlet opened on the S. slope of the mountain IV $A^{\beta\,38}$ and adjoining IV $A^{\beta\,19}$ on the N.E. It is shown by B. & M. but *not* by Lohrmann, and is the eighth in order upon IV A^{β}. Longest diameter (which aligns with N.W. angle of IV $A^{\beta\,19}$, and S. angle of IV $A^{\beta\,16}$)=5″·31. Diameter at a right angle to the normal line, viz. a line joining N. edge of *Dionysius* and the S. edge of *Agrippa*,=3″·54, mag. 0·26. With a morning terminator advanced beyond *Copernicus*, the interior shadow of the W. rim is crescentiform, the chord being at a right angle to the direction of the longest diameter; breadth of shadow 2″·70, of illuminated interior 3″·17. Proportion of shadow to illuminated interior as 1 : 1·174. It is *deeper* than the somewhat similarly situated crater IV $A^{\beta\,15}$.

This craterlet is well situated for observing the effect of libration on the precipitous W.N.W. wall of *Hipparchus*. This wall, which has a direction S.S.W.–N.N.E., is at times brought by libration into such a position that the eye looks along its E.S.E. slope; but when the moon is in the opposite part of her orbit, it is so situated with regard to the eye that the slope is more readily seen, and probably a portion of it *lower than* the craterlet may be detected. In the latter case it would really be further from the eye; but the slope would be seen under a larger angle, while the craterlet would by foreshortening be seen under a smaller angle; the difference, however, would be but slight, and scarcely appreciable by the eye.

22(x). A small eminence nearly central in IV $A^{\beta\,16}$ (*Horrox*), diameter 3″·17.

23. A small hillock in IV $A^{\beta\,16}$ N.N.E. of IV $A^{\beta\,22}$.

24. A small hillock in IV $A^{\beta\,16}$ S.S.E. of IV $A^{\beta\,22}$.

25(x). The lower part of the E. interior slope of IV $A^{\beta\,16}$. The upper part is IV $A^{\alpha\,34}$.

26. A mountain N. of *Horrox*; length of crest 4″·94, breadth of base 3″·5. This mountain is elevated *on* the N. slope of IV $^{\beta\,16}$.

27. A mountain W.N.W. of IV $A^{\beta\,26}$; length of crest 4″·01, breadth of base 4″·01. The crest of this mountain is a continuation of that of IV $A^{\beta\,26}$, with a slight break between them. The W. end is separated from the E. exterior slope of IV $A^{\beta\,14}$ by a narrow valley which lies in the line of fault IV $A^{\beta\,20}$, and opens into the broader valley IV $A^{\beta\,31}$ (see IV $A^{\beta\,31}$).

28. A crateriform depression on the N.W. slope of *Horrox*; diameter 5″·13, mag. 0·30.

**29(x). A mountain W. of *Rhæticus*. Well shown by Lohrmann, S. of his 62, Sec. I., but indifferently by B. & M. Length of crest 6″·71, breadth of base 8″·02. This mountain, with IV $A^{\beta\,52}$ (Lohrmann's 62, Sec. I.), forms the W. part of the secondary rampart around *Rhæticus* (see letterpress to areas IV A^{α}, IV A^{ζ}, p. 12, and Report Brit. Assoc. 1866, p. 248).

30(x). A depression N. of IV $A^{\beta\,26}$; length E.–W. 10″·25, breadth N.–S. 6″·25. This depression, which is *very shallow*, lies in the valley IV $A^{\beta\,31}$, and also in the line of cliffs IV A^{α} W.N.W.–E.S.E., No. 1 (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 34, and Report Brit. Assoc. 1866, p. 270). The fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$ appears to have *dislocated* this depression, as there is the appearance of the W. part on the higher level west of

the "fault." It is not a little remarkable that while a range of cliffs somewhat of the same nature as IV A^{α} W.N.W.–E.S.E., No. 1, extends from IV $A^{\beta\,13}$ towards *Horrox*, the craters IV $A^{\beta\,14}$ and IV $A^{\beta 15}$ with *Horrox* forming its S.E. portion, the crater IV $A^{\beta 3}$, and the cliffs IV $A^{\beta\,4}$, IV $A^{\beta\,10}$, IV $A^{\beta\,43}$, and IV $A^{\beta\,44}$ lie in the prolongation of IV A^{α} W.N.W.–E.S.E., No. 1. Does this point to a focus of *upburst* in the neighbourhood of *Horrox*, *contemporaneous* with the fault IV$A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$, and marked by the three large openings, *Horrox*, IV $A^{\beta\,14}$, and IV $A^{\beta\,19}$? If so, the line of cliffs extending from IV $A^{\alpha\,51}$ to IV $A^{\beta\,13}$ would probably be more ancient than the "fault," the upburst occurring S. of the line of cliffs. It is to be remarked that on the line of cliffs a few small craters only are found, of which IV $A^{\alpha\,7}$ and IV $A^{\beta\,3}$ are the principal, scarcely exceeding 8″ in diameter, and at a considerable distance from each other. In describing the fault (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 20, and Report. Brit. Assoc. 1866, p. 256), we suggested that it might be more recent than the "ray from Tycho," on which the steep and rugged W. border of *Albategnius* occurs. On the parallel ray to the E. we noticed two points of upburst, one near IV $A^{\zeta\,36}$, the other near IV $A^{\zeta\,32}$ (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 39, and Report Brit. Assoc. 1866, p. 275), the activity of which might be more ancient than that of IV $A^{\eta\,2}$. Should these considerations at all approximate to the truth, then we have a probable recent epoch for the production of the group of craters near the W. portion of *Hipparchus*. The close similarity, both in form and direction, of the valleys IV $A^{\alpha\,32}$ and IV $A^{\eta\,18}$ on opposite sides of *Hipparchus* also points to the priority of age of the line of cliffs in which IV $A^{\alpha\,32}$ occurs, as compared with the floor of *Hipparchus,* which appears to be more recent.

31(x). The S.S.W. part of the valley IV $A^{\alpha\,77}$.

This valley is interrupted but not obliterated by the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$. At first, in the neighbourhood of IV $A^{\alpha\,78}$, it is wide; but as the fault is approached it becomes much narrower. The W. side of the crateriform depression IV $A^{\beta\,15}$ appears to be part of the W. slope of this valley, on which the E. rim of the crater IV $A^{\beta\,14}$ has protruded, which indicates a more recent epoch for the production of IV $A^{\beta\,14}$. Beyond the group connecting IV $A^{\beta\,14}$ with IV $A^{\beta\,16}$, the valley IV $A^{\alpha\,77}$ IV $A^{\beta\,31}$ can be traced as a narrow *dark* cleft through the ascent to the bright spot IV $A^{\beta\,37}$. This cleft is not in Schmidt's catalogue.

32. A craterlet S. of IV $A^{\beta 33}$, E. of IV $A^{\beta 20}$, 2″·70, mag. 0·16. The fifteenth in order on area IV A^{β}.

33. The W. part of the S. portion (IV $A^{\alpha\,48}$) of the second wall of *Rhæticus* (see letterpress to areas IV A^{α}, IV A^{ζ}, p. 12, and Report Brit. Assoc. 1866, p. 248). It has been dislocated by the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$.

34. A pit S.S.E. of IV $A^{\beta\,15}$ adjoining IV $A^{\beta\,28}$.

This pit is surrounded by a broad hilly border; longest diameter of border $=7''{\cdot}18$, shortest$=4''{\cdot}94$. It, with the E. border of IV $A^{\beta\,15}$, is situated *very exactly* in the line of fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$; IV $A^{\beta\,15}$, IV $A^{\beta\,34}$, and IV $A^{\beta\,28}$ form a connexion between IV $A^{\beta\,14}$ and IV $A^{\beta\,16}$.

35(x). A mountain W.N.W. of IV $A^{\beta\,19}$, on the line of fault IV $A^{\eta\,35}$ IV $A^{\beta\,63}$, also on the "ray from Tycho" on which *Bessel* is situated. The two intersect at this mountain, which appears to have been thrust forward in the line of "cleft" IV $A^{\beta\,95}$.

36. The mountain-peak at the W. angle of IV $A^{\beta\,18}$.

37. The bright white spot (crater) on the W. slope of IV $A^{\beta\,38}$, the twelfth crater in order on IV A^{β}.

This spot should be assiduously watched. The spot IV Aζ^{39} IV A$^{a\,17}$, described in letterpress to areas IV A^{a}, IV Aζ, pp. 15 and 26, and Report Brit. Assoc. 1866, pp. 251 and 262, as a bright spot, has been seen by the author and by the Rev. W. O. Williams *as a crater*—on one occasion (Oct. 18, 1867) by Mr. Williams *conspicuously so with a central cone casting a shadow.* In the December lunation Mr. Williams was unable to detect any trace of a crater; but on January 3, 1868, the succeeding lunation, Mr. Baxendell saw it as a shallow crater about $\frac{3}{4}$ of the diameter of IV A$^{a\,7}$. Mr. Williams has steadily continued his observations on this spot, from 1867, Oct. 7, to 1868, May 7, which I have arranged in the order of the sun's altitude above it; and as this arrangement illustrates the use of the Table on pp. 10, 11, it may be well to introduce it here, both as an example of referring observations to solar altitudes, and also as indicative of the changes of appearance dependent on the angle of illumination.

Observations of IV A$^{a\,17}$ IV Aζ^{39}; Latitude 5° S., Longitude 2° West.

No.	Date.	G.M.T.	Authority.	☉'s alt.	Brightness.	Character.
				Morning Illumination.		
1.	1867, May 11.	8½	Birt	° ° 0–6	°	A shallow crater.
2.	1868, Feb. 1.	5–6	Williams	6–12	......	Crater well seen.
3.	1868, Mar. 31.	7½	Birt	6–12	......	Crater well defined.
4.	1868, Jan. 3.	5–6	Williams	12–18	......	Discerned central cone, not certain.
5.	1868, Jan. 3.		Baxendell	12–18	......	Well-marked shallow crater.
6.	1867, Nov. 5.	9–10	Williams	18–24	7	Very bright, streak of interior shadow on the west.
7.	1868, April 1.	5–6	Williams	18–24	4	Whitish patch of light.
8.	1867, Dec. 5.	6–8	Williams	24–30	5	Whitish spot; no crater.
9.	1868, May 1.	10–11	Williams	24–30	......	Whitish patch, line of interior shadow on the west.
10.	1867, Oct. 7.	8½–10	Williams	24–30	......	A very bright spot.
11.	1867, Nov. 6.	8–10	Williams	30–36	6	A bright patch of light; streak of shadow scarcely discernible.
12.	1868, April 2.	5–6	Williams	30–36	4	Whitish patch of light.
13.	1868, April 2.	8½	Birt	30–36	4	Very shallow crater with interior shadow.
14.	1867, Dec. 6.	9–10	Williams	36–42	5	Whitish spot; no crater.
15.	1868, May 2.	6½–10	Williams	36–42	......	Long patch of light to east.
16.	1868, May 4.	10½–11½	Williams	48–54	......	Two bright spots.
17.	1868, May 5.	10½–11½	Williams	60–66	......	Two bright spots nearly equal and circular.
18.	1868, May 6.	9¾–10¼	Birt	72–78	6·5	Two bright spots.
19.	1868, May 7.	11¼–12	Williams	83–85	......	Two bright spots; E. spot largest.
				Evening Illumination.		
20.	1867, Nov. 15	18–20	Williams	36–30	10	Very bright.
21.	1868, Feb. 12.	20½	Williams	30–24	6, 4	Crater very conspicuous; with east peak very bright; 6°.
22.	1867, Oct. 17.	13–15	Williams	30–24	......	Crater very conspicuous.
23.	1867, Oct. 17.	13½	Ingall	30–24	......	Drawn as a crater.
24.	1867, Oct. 18.	17–19	Williams	18–12	......	Crater very conspicuous; small central cone casting a shadow.
25.	1868, Jan. 15.	20½	Williams	12– 6	......	The crater conspicuous, with interior shadow on east, fully equal to that of IV A$^{a\,7}$.

The desideratum connected with spots of this nature is not so much the detection of physical change as the *exact* determination of the value or extent of apparent change dependent upon variations of distance, libration, and angle of illumination; for until such determinations are reduced to *numerical* values, we are not in a position to decide upon the absolute *fixity* of such objects; nor can we be certain that there is more than apparent change until a large number of observations are discussed with especial reference to the elements above named.

The Rev. T. W. Webb, in contrasting his seeings of *Eratosthenes* with the description of that crater by Beer and Mädler in 'Der Mond,' has the following very important remarks. Speaking of the appearance which *Eratosthenes* presented on the evening of Nov. 8, 1867, he says, "*Eratosthenes* now all in local colour; from point of junction of *Apennines* round the E. semicircle, the outside glacis of wall shows a curious dark-grey border. This is penetrated in two places by the streaks of *Copernicus*, which extend perhaps across *Eratosthenes* itself. Curious as to chronological sequence . . . It is just possible, however," Mr. Webb continues, "that some process affecting the reflective power of the surface may at this time be working here; for B. & M. say that this crater is 'in full moon not very distinct'[a]: we only see a very undefined faint light spot in a vicinity almost equally luminous. No mention is made of any darker portions, or of their being so situated as to indicate the position of the ring; and the description certainly does not tally well with present appearances. This is a peculiarly suitable spot for examining the question whether the *Full-moon markings* are unchangeable. Fixity, of course, if established by a long course of observation here, or anywhere else, would be no argument for its universal prevalence, since a state of quiescence in this respect might be attained at very different epochs in different regions; but should the reverse be clearly ascertained in a single well-marked, even though minute, case, it need not be mentioned that one distinct, incontrovertible affirmation weighs down any number of negative instances, and merely throws back the date of their change to a prehistoric period."—Intellectual Observer, vol. xii. pp. 435, 436.

**38(x). A mountain-peak on the W. border of *Hipparchus*, the culminating point of the mountain-mass in IV A^{β} 18.

The high mountain-border on which IV A^{β} 38 is situated, extends from the mouth of the valley IV A^{η} 31, in the depression IV A^{η} 32, to the N. part of the peak IV A^{β} 47 (see *ante*, p. 22).

*39(x). A mountain-arm lying in the shallow depression IV A^{β} 41, which it scarcely fills. Its direction is N.E.–S.W.; it springs from the S. end of the depression IV A^{β} 40, between IV A^{β} 4 and IV A^{β} 10; its highest point is the N.E., from which it gradually declines in altitude to the S.W. part of the depression IV A^{β} 41. Length of crest 8″·95, breadth of base 6″·25 (see *ante*, pp. 15, 16).

40(x). A depression having somewhat of the crater character, between IV A^{β} 4 and IV A^{β} 10, which rise to a considerable elevation on the W.N.W. and E.S.E. It is closed on the N. by lower hills, and on the S. by the N.E. extremity of the mountain-arm IV A^{β} 39.

41. The shallow depression in which IV A^{β} 39 is situated.

42. A "fault" passing through IV A^{β} 69, the E. foot of IV A^{β} 71, grazing the E. foot of IV A^{β} 73, along the axis of IV A^{β} 10, and the W. mountain-border of IV A^{β} 49.

[a] It is necessary to bear in mind that Mr. Webb's aperture is much larger than the one with which B. & M. observed; it would nevertheless be important for gentlemen possessed of smaller apertures to examine *Eratosthenes* with the view of making out the details recorded by Mr. Webb.

This "fault" is the westernmost of *three* that are nearly parallel and equidistant, viz. IV A^{β} 42, IV A^{β} 51, and IV A^{β} 20. These agree more or less in the steeper escarpments of the mountains found on them facing the E.S.E., their general direction being S.S.W.–N.N.E. Of the three, the fault IV A^{η} 11 IV A^{β} 20 IV A^{α} 72 (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 19, and Report Brit. Assoc. 1866, p. 255) is the longest and most distinctly marked as well as the easternmost. It is situated on the W. border of *Hipparchus*, and separates an elevated from a depressed tract of surface. If the parallelism of these faults points to a contemporaneity of origin, may we not recognize here the simultaneous operation of the upheaving force over a comparatively large area? It may be remarked, in connexion with this suggestion, that the *two* mountain-ranges forming the S.S.W. and N.N.E. boundaries of the depressed portion E.S.E. of the main fault IV A^{η} 11 IV A^{β} 20 IV A^{α} 72 have their steep escarpments towards depressed surfaces.

With regard to the comparative ages of these faults, we have already suggested (letterpress, areas IV A^{α}, IV A^{ζ} p. 20, and Report Brit. Assoc. 1866, p. 256) that the fault IV A^{η} 11 IV A^{β} 20 IV A^{α} 72 is more recent than the "ray from Tycho" which it intersects; this suggestion is founded upon the fact that the "fault" is continuous throughout, but the "ray" is interrupted at the point of intersection.

*43(x). A somewhat low mountain-range between IV A^{β} 10 and IV A^{β} 44.

**44(x). A mountain-range S.E. of IV A^{β} 43, situated on the line of circumvallation around IV A^{β} 2 IV A^{γ} 3.

The short mountain-ranges IV A^{β} 4, IV A^{β} 10, IV A^{β} 43, and IV A^{β} 44, with the crater IV A^{β} 3 and the intervening depressions, nearly form a radius from the centre to the circumference of the supposed ancient walled plain in which IV A^{β} 2 IV A^{γ} 3 is situated. There are but few irregularities on the remaining portion of the plain. It is probable these mountains are posterior in date to the plain.

45(x). The crateriform depression between IV A^{β} 10 and IV A^{β} 43.

46. The valley between IV A^{β} 43 and IV A^{β} 44.

This valley can be traced in a serpentine direction from between IV A^{β} 43 and IV A^{β} 44, past the W. end of IV A^{β} 55, which slopes towards it, also past IV A^{β} 57, which slopes towards the fault IV A^{β} 42, *through which* IV A^{β} 46 passes.

**47(x). A mountain-peak on the W. border of *Hipparchus*, N.N.E. of IV A^{β} 38. It is also on the fault IV A^{η} 11 IV A^{β} 20 IV A^{α} 72.

48. A wide opening or inlet in the mountain-border of *Hipparchus*, between the two mountain-peaks IV A^{β} 38 and IV A^{β} 47.

**49. A depression W. of IV A^{β} 11, and between it and IV A^{β} 54. It is situated on the line of "circumvallation" around IV A^{β} 2 IV A^{γ} 3.

50. A shallow depression or crater on the S.W. border of IV A^{β} 11, diameter $8''{\cdot}02$, mag. 0·47, which includes a continuation of the depression northwards (see IV A^{β} 59).

51. A fault parallel with and between IV A^{β} 42 and IV A^{β} 20.

This fault is the shortest of the three nearly parallel (see IV A^{β} 42). It extends northward as far as the smooth surface on which *Triesnecker* is situated, and passes between IV A^{β} 29 and IV A^{β} 52, along the W. border of IV A^{β} 53 and the low ridge IV A^{β} 77, towards the crater IV A^{β} 65, where it meets the line of fault IV A^{η} 35 IV A^{β} 63.

**52. A mountain-range forming the E.N.E. border of IV A^{β} 11, and part of the second wall of *Rhæticus* on the west. It is 62 of Lohrmann's Sec. I.

*53(x). A semicrater on the "fault" IV A^{β} 51, S.S.E. of IV A^{β} 11. Length

of W. arm 4″·47, of E. arm 5″·78, opening between the arms 8″·02. Not shown by B. & M. but by Lohrmann.

This semicrater appears to have been modified by the "fault" IV $A^{\beta\,51}$, by which a kind of buttress has been thrown up in the interior against the N.W. rim. It has a craterlet, IV $A^{\beta\,99}$, on the S. end of the buttress.

54. The S.W. end of the mountain-range I $A^{\beta\,28}$ (?), forming the W. mountain-border of IV $A^{\beta\,49}$.

On Rutherford's photogram, IV $A^{\beta\,11}$ and IV $A^{\beta\,49}$ are enclosed by mountains, of which IV $A^{\beta\,52}$ is on the E. and IV $A^{\beta\,54}$ on the W. IV $A^{\beta\,52}$ is clearly Lohrmann's 62, Sec. I. The mountain in area I A^{β} forming the N. edge of IV $A^{\beta\,49}$, most probably is Lohrmann's 64, Sec. I., although it does not occupy the position which Lohrmann assigns it. IV $A^{\beta\,54}$ occupies the position of the N. end of Lohrmann's 63, Sec. I. Lohrmann appears to be in error here, inasmu chas he makes the chain 63, Sec. I., *continuous* from a point S. of the latitude of IV $A^{\beta\,3}$ (60, Sec. I.) to a point a little N. of the latitude of the N. edge of J, Sec. I. On the photogram IV $A^{\beta\,10}$ and IV $A^{\beta\,54}$ are *disconnected*, IV $A^{\beta\,10}$ occupying the position of the S. end of 63, Sec. I., and IV $A^{\beta\,54}$, as before mentioned, the N. end. The valley IV $A^{\beta\,46}$ passes between them. See *ante*, p. 18, IV $A^{\beta\,10}$.

The *direction* of Lohrmann's chain is also greatly in error; he makes it align with E and B of Sec. I. (IV $A^{\beta\,19}$, and *Hind*). The true alignment is very different, viz. the line of fault IV $A^{\beta\,42}$.

55. A low mountain running E. and W.; length of crest 10″·26, breadth of base 4″·48.

This mountain is situated between IV $A^{\beta\,44}$ and IV $A^{\beta\,11}$; its base approaches in form to a parallelogram, the crest forming the diagonal.

56. A small hillock on the line of fault IV $A^{\beta\,51}$, between IV $A^{\beta\,52}$ and IV $A^{\beta\,53}$; it is close to the S.E. foot of IV $A^{\beta\,11}$.

57. A low mountain N.N.E. of the depression IV $A^{\beta\,45}$; length of crest 6″·71, breadth of base 7″·18. 1867, Dec. 3, 10^{h}, with the Royal Astronomical Society's Sheepshanks telescope, No. 5, aperture 2·75 inches, power 100, I identified IV $A^{\beta\,57}$, IV $A^{\beta\,54}$, and I $A^{\beta\,28}$ as Lohrmann's 63, Sec. I. I also proved the inaccuracy of Lohrmann in continuing the chain to IV $A^{\beta\,10}$. See IV $A^{\beta\,54}$.

58. A low mountain between IV $A^{\beta\,11}$ and IV $A^{\beta\,55}$; length of crest 7″·18, breadth of base 7″·18. The three mountains IV $A^{\beta\,55}$, IV $A^{\beta\,57}$, and IV $A^{\beta\,58}$ mark an area of subordinate elevation between the faults IV $A^{\beta\,42}$ and IV $A^{\beta\,51}$.

59. A shallow depression on the W. slope of IV $A^{\beta\,11}$, N. of IV $A^{\beta\,50}$.

60. A craterlet on the E. slope of IV $A^{\beta\,10}$ between the crest and the fault IV $A^{\beta\,42}$. It is situated on the higher land W. of the "fault," and is in this respect somewhat similar to the craters IV $A^{\beta\,15}$, IV $A^{\beta\,21}$, and IV $A^{\beta\,65}$; 2″·7, mag. 0·16, the fourteenth in order upon IV A^{β}.

61. The ridge crossing IV $A^{\beta\,11}$ from S. to N.

This ridge was discovered on Dec. 3, 10^{h}, 1867, with the Royal Astronomical Society's Sheepshanks telescope, No. 5, aperture 2·75 inches, power 100. The observation is thus recorded:—"IV $A^{\beta\,57}$ and IV $A^{\beta\,29}$ IV $A^{\beta\,52}$ form the W. and E. boundaries of Lohrmann's plain J, Sec. I., containing the two low mountain-chains and central mountain. The two low mountain-chains I neither identify on the moon nor on the photogram; but I see on the moon a mountain between them [IV $A^{\beta\,57}$ and IV $A^{\beta\,29}$ IV $A^{\beta\,52}$], which is not the central mountain of J, Sec. I., but the mountain-ridge between the two, *i. e.* IV $A^{\beta\,57}$ and IV $A^{\beta\,29}$ IV $A^{\beta\,52}$. I apprehend the mountain-ridge

IV $A^{\beta\,61}$ of IV $A^{\beta\,11}$ is the E. of the two low ridges of Lohrmann. Between this and his 63, Sec. I., is the depression IV $A^{\beta\,49}$, not shown by him; and instead of a *plain* and *central mountain* between the ridge IV $A^{\beta\,61}$ and IV $A^{\beta\,29}$ IV $A^{\beta\,52}$, the S. part of the space is filled with the crater IV $A^{\beta\,12}$, and the N. part *dips* to the N. angle of the formation IV $A^{\beta\,11}$ and I $A^{\beta\,30}$" (see IV $A^{\beta\,11}$).—[W. R. B.]

62. The N.N.W. part of the fault IV $A^{\eta\,23}$ IV $A^{\beta\,62}$. Direction S.S.E.–N.N.W., face towards E.N.E.

This fault is nearly coincident with the "ray from Tycho" on which Bessel is situated. It takes its rise on the E. border of *Hind*, and passes, but does not obliterate, the narrow valley IV $A^{\eta\,18}$. From the S.W. end of the valley IV $A^{\eta\,6}$, which is on the lower level E.N.E. of the fault, to the long narrow valley or cleft[a] IV $A^{\eta\,11}$ (crater-rill No. 362 of Schmidt), where it intersects but does not divide the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$ (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 20, and Report Brit. Assoc. 1866, p. 256), it is nearly coincident with the W. border of Hipparchus. The surface has been greatly disturbed near the point of junction of this fault with the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$, in such a manner as to indicate that the force which produced IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$ has been exerted at an epoch more recent than that which produced IV $A^{\eta\,23}$ IV $A^{\beta\,62}$. It is in this disturbed locality that the craters IV $A^{\beta\,19}$ and IV $A^{\beta\,21}$ have been opened. After grazing the W. wall of IV $A^{\beta\,19}$, the fault IV $A^{\eta\,23}$ IV $A^{\beta\,62}$ passes onward by the W. wall of the depression IV $A^{\beta\,18}$, just W. of the crater

[a] It has been decided, upon mature consideration, to substitute the term "cleft" for "rill" as being more significant and comprehensive. It may be important to mention that a "cleft" differs from a "fault" in one essential particular; for example, a "fault" marks a *line of dislocation*, which in some instances is characterized by an elevation of the surface on one side, and a depression on the other *without presenting the appearance of a crack or narrow valley*. In other cases, long narrow depressions may be found, mostly in lines of fault, and often in the same line with cliffs which have been upheaved probably by the same agency, and near the same epoch at which the narrow valley or "cleft" has been produced. The term "fault" is consequently employed to signify the result of a force *apparently* acting in many instances more or less in radial lines from a centre or focus of disturbance, such as *Tycho*, from which numerous lines of "fault" diverge (see Report Brit. Assoc. 1847, p. 61), while the term "cleft" is used to signify a partial result only, and one which has been manifested in *depression* as contradistinguished from *elevation*. (See 'Intellectual Observer,' No. LXVII. August 1867, vol. xii. p. 52 *et seq.* for some interesting remarks on Lunar Clefts by the Rev. T. W. Webb.)

It may be well here to quote Sir C. Lyell's definition of a "fault" as used in geological language, 'Principles of Geology,' ninth edition, 1853, (Glossary) p. 805. "Fault, in the language of miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure varying in width from a mere line to several feet."

It is clear that the signification of the term "fault," as applied to the moon, cannot be of precisely the same nature as when it is used in geology; for we cannot observe "faults" of this kind. Nevertheless the general principle holds good, viz. the elevation or depression of the *surface plane on one side of the Lunar line of fault*. It has been recognized as a peculiarity of geological "faults," that the *higher* portions of the dislocated beds are usually on the sides towards which the "faults" incline in ascending (Report Brit. Assoc. 1847, p. 62), so that the ends of the *raised* strata present steep escarpments towards the depressed portions—phenomena of frequent occurrence on the moon's surface. In the areas already mapped, we have the escarpments of the cliffs facing the lower level IV $A^{\alpha\,11}$, the level of the floor of *Hipparchus* being nearly identical with the summits of the cliffs (see letterpress to areas IV A^{α} and IV A^{ζ}, pp. 12, 13, and Report Brit. Assoc. 1866, pp. 248, 249)—also the steep escarpments of the mountains between IV $A^{\beta\,19}$ and IV $A^{\beta\,14}$ facing the floor of *Hipparchus*, while the general level W. of the mountains is much higher than the floor on the E. Numerous other examples may easily be given. Dislocations of mountains and craters are very apparent on lines of "fault."

IV $A^{\beta\,65}$, and grazes the N.E. end of the mountain-arm IV $A^{\beta\,39}$. The precipitous E. face of the mountain IV $A^{\beta\,4}$ appears to have been produced by this fault.

63. The N. part of the fault IV $A^{\eta\,35}$ IV $A^{\beta\,63}$. Direction N. by W.–S. by E.

This fault appears to have originated in connexion with the outburst which produced the crater IV $A^{\eta\,2}$, as it forms one of a system of faults N. and S. of that light-centre (see fig. 1, *ante* p. 13). This fault, on the N. of IV $A^{\eta\,2}$, is first apparent in the mountain-chain IV $A^{\eta\,12}$, which is situated on it. From this mountain-chain the faults IV $A^{\eta\,11}$ and IV $A^{\eta\,35}$ diverge. The course of IV $A^{\eta\,11}$ is described in letterpress, areas IV A^{α}, IV A^{ζ}, pp. 19, 20, and Report Brit. Assoc. 1866, pp. 255, 256. IV $A^{\eta\,35}$ IV $A^{\beta\,63}$ passes along the W. range of IV $A^{\eta\,12}$ to the W. wall of IV $A^{\beta\,18}$, where it intersects the faults IV $A^{\eta\,23}$, IV $A^{\beta\,62}$, on the "ray from Tycho." It then passes along the range on which IV $A^{\beta\,65}$ is situated, where it intersects the fault IV $A^{\beta\,51}$. It next passes through IV $A^{\beta\,44}$ to the W. border of IV $A^{\beta\,49}$, where it intersects the fault IV $A^{\beta\,42}$, and is traced still more northerly through the mountain I $A^{\beta\,31}$ (Lohr. Sec. I. 65) towards Manilius.

The evidence of the more recent origin of this fault than the "ray from Tycho," as compared with that of the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$ (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 20, and Report Brit. Assoc. 1866, p. 256), is not so striking as in that instance. There does not appear at the point of intersection to be any breaking through of the fault IV $A^{\eta\,23}$ IV $A^{\beta\,62}$ by the fault IV $A^{\eta\,35}$ IV $A^{\beta\,63}$; and therefore it is not so easy to determine whether IV $A^{\eta\,35}$ IV $A^{\beta\,63}$ be posterior to the ray from Tycho and contemporaneous with IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$, or otherwise. There can, however, be very little doubt of its connexion with the crater IV $A^{\eta\,2}$, and that it forms one of a system of "faults" of which that crater is the centre.

64. A mountain-peak at the S. end of IV $A^{\beta\,35}$ on the line of fault IV $A^{\eta\,35}$ IV $A^{\beta\,63}$.

65. A shallow crater W. of IV $A^{\beta\,14}$, on the line of fault IV $A^{\eta\,35}$ IV $A^{\beta\,63}$. Longest diameter (on a line passing through IV $A^{\beta\,14}$) 6″·71, shortest (at right angles to this line) 4″·47, mag. 0·33, the fifth crater in order upon area IV A^{β}, 1865, March 6.

This crater is shown by B. & M. but not by Lohrmann. B. & M. give a crater between IV $A^{\beta\,65}$ and IV $A^{\beta\,21}$, which is in Lohrmann, and on Rutherford's photogram, 1865, March 6, appears to be the N.E. angle of the depression IV $A^{\beta\,18}$ (see IV $A^{\beta\,18}$); IV $A^{\beta\,65}$ appears to be shallow, and is situated on a mountain-mass which is nearly in the line of fault IV $A^{\beta\,51}$. With a morning terminator past *Copernicus*, the shadow, which is scarcely discernible, measures 2″·7; the longest diameter = 6″·71; therefore the proportion of shadow to illuminated interior is as 1 to 1·483. It is noteworthy that IV $A^{\beta\,65}$, IV $A^{\beta\,15}$, and IV $A^{\beta\,21}$ are similarly situated with regard to the mountains on which they are opened; all three are near faults, and all are suggestive of the exertion of a force by which the masses on which they occur were thrown towards S.S.E., the direction of the faults in this neighbourhood coincident with the "rays from Tycho."

66. The mountain-mass on which IV $A^{\beta\,65}$ is opened. Length of crest 11″·65, breadth of base at S. end, including crater, 12″·03, at N. end 8″·25.

67. A low mountain-range in continuation of IV $A^{\beta\,43}$; it has upon it two peaks.

68. A plateau west of, or a very gentle slope westward from, the S.W. rim of IV $A^{\beta\,19}$.

*69. A shallow depression E. of IV $A^{\beta\,70}$, probably 58 of Lohrmann's Sec. I.

Lohrmann appears not to have made the distinction between this depression and the plain that extends eastward from it, as far as the mountains IV $A^{\beta\,61}$, IV $A^{\beta\,35}$, and IV $A^{\beta\,36}$, but has given between IV $A^{\beta\,70}$ and these mountains a smooth plain. The depression IV $A^{\beta\,69}$ is well marked in Rutherford's photogram.

*70. A mountain-range in the chain that extends from the junction of *Ptolemæus* and *Alphonsus* to and beyond IV $A^{\beta\,81}$. This range "forks" into two small branches at the S. end. Length of crest from N. end to fork 6″·71, from fork to S.E. end 4″·01, from fork to S.W. end 7″·18.

71. The depression enclosed by IV $A^{\beta\,19}$, IV $A^{\beta\,64}$, IV $A^{\beta\,35}$, IV $A^{\beta\,36}$, IV $A^{\beta\,18}$, IV $A^{\beta\,38}$, and IV $A^{\beta\,21}$. It is not shown by Lohrmann as a depression.

This depression is situated in so very interesting a group of objects, the S. part of which occurs in area IV A^{η}, that, anticipating to some extent a notice of the objects in that area, it may be well to describe the group in this place.

This group consists of IV $A^{\eta\,6}$, IV $A^{\eta\,12}$, IV $A^{\eta\,13}$, IV $A^{\eta\,21}$, the partly enclosed surface IV $A^{\eta\,32}$, with the valley IV $A^{\eta\,11}$, and the mountains IV $A^{\eta\,20}$, IV $A^{\eta\,30}$, IV $A^{\eta\,33}$, and IV $A^{\eta\,34}$. Were these objects in a *level* portion of the moon, IV $A^{\eta\,32}$ would present the aspect of a depression partly surrounded by mountains. As it is, it has greatly the appearance of one of those partially destroyed craters which are met with on the borders of the *Maria*; and it is not a little remarkable that the mountainous boundary ends abruptly both on the S.E. and N.W. at the line of cliffs in the chain from the junction of *Ptolemæus* and *Alphonsus* to and beyond IV $A^{\beta\,81}$, the portion S.E. of the valley IV $A^{\eta\,11}$ facing the depressed surface of *Hipparchus*. There is not the slightest indication of a complete boundary having existed at any anterior epoch similar to IV $A^{\zeta\,58}$ (see letterpress, areas IV A^{α}, IV A^{ζ}, p. 27, and Report Brit. Assoc. 1866, p. 263); indeed the mountains are scarcely disposed in the segment of a ring. The object which presents the nearest analogy to IV $A^{\eta\,32}$ is IV $A^{\alpha\,10}$; and it is noteworthy that the southern mountainous boundaries of both are curved, the convexities being towards the S.; and both are traversed by valleys running in the same direction. IV $A^{\eta\,32}$, as it is seen on Rutherford's photogram, and also on the moon, is very individualized; it forms, however, only part of a larger formation, which is not the less well and distinctly marked. Among the remaining objects are IV $A^{\beta\,64}$, IV $A^{\beta\,35}$, and IV $A^{\beta\,36}$, three mountains in a line with IV $A^{\eta\,12}$, IV $A^{\eta\,13}$, and IV $A^{\eta\,21}$, but separated from them by the plateau or slope IV $A^{\beta\,63}$. Together these mountains form the W. wall of the larger formation, the N. boundary of which consists of the low N.N.W. wall of the depression IV $A^{\beta\,18}$, and the N.E. foot of the mountain IV $A^{\beta\,47}$; the E.S.E. boundary consists of the cliffs bordering *Hipparchus* on the W.N.W., of which the highest point is IV $A^{\beta\,38}$.

The striking peculiarities of this formation are the depression IV $A^{\eta\,32}$ at its S. end, and the elevated boss filling IV $A^{\beta\,18}$ at its N. end; so that there is a gradual slope from N. to S. Two craters are opened upon it, IV $A^{\beta\,19}$ and IV $A^{\beta\,21}$. IV $A^{\beta\,21}$ is peculiarly situated, as if the northern mass had been *heaved* forwards towards the S.E. The faults IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$ and IV $A^{\eta\,23}$ IV $A^{\beta\,62}$ include a great portion of this formation, which is traversed by the "ray from Tycho" on which *Bessel* is situated. This "ray" passes close to IV $A^{\beta\,19}$, which is situated on its E.N.E. slope.

72. A narrow shallow valley extending from the mountain IV $A^{\beta\,64}$ into the depression IV $A^{\beta\,69}$; length 17″·43, breadth between IV $A^{\beta\,64}$ and IV $A^{\beta\,35}$ 3″·54, breadth in IV $A^{\beta\,69}$ 2″·24. This valley appears to be posterior in date to the depression IV $A^{\beta\,69}$, or at least to the very low E. wall, which has been broken through in the line of valley.

73. A mountain S.S.W. of IV $A^{\beta\,45}$. Length of crest S.S.W.–N.N.E. 11″·19, length of crest on N.W. 5″·31. It is in the line of fault IV $A^{\beta\,42}$.

74. A mountain-mass lying in a shallow depression between IV $A^{\beta\,70}$ and IV $A^{\beta\,73}$, near the line of circumvallation around IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$.

The base of the mountain-mass is of an elliptical form. Longest diameter 13″·42, nearly in a line with the summits of IV $A^{\beta\,36}$ and IV $A^{\beta\,38}$; shortest diameter at right angles, 8″·95. The summit is on the N. of the longest diameter.

75. A mountain-peak on the N. border of IV $A^{\beta\,69}$, near the line of "circumvallation" around IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$.

†76. A small depression at the E. foot of IV $A^{\beta\,74}$.

77. A low ridge in continuation of the interior W. wall of IV $A^{\beta\,53}$, coincident with the fault IV $A^{\beta\,51}$; length 7″·64.

78(x). A shallow depression E.S.E. of and in continuation of the line of cliffs IV $A^{\beta\,4}$ to IV $A^{\beta\,44}$.

The interior of this depression appears as a *white spot* on Rutherford's photogram, 1865, March 6. 1868, May 1^{d} 9^{h} 45^{m} G. M. T., I observed it with the Crossley equatorial of 7·3 inches aperture, and saw it as a round craterlet with interior shadow of about ·33, diameter of craterlet=1. It was slightly larger than IV $A^{\beta\,37}$, and is the eleventh in order on IV A^{β}. On May 2^{d} 7^{h} 45^{m} G. M. T. it exhibited some approximation to the class of "light-centres" (see Report Brit. Assoc. 1866, p. 218). I have also recorded that in 1868, on March 31^{d} 8^{h} 30^{m} G. M. T., and May 30^{d} 10^{h} 20^{m} G. M. T., it was seen as a crater with the Royal Astronomical Society's Sheepshanks Telescope, No. 5.

79. A cleft from the end N. of IV $A^{\beta\,44}$ to IV $A^{\beta\,78}$; length 9″·79; not in Schmidt's catalogue.

80. A mountain between IV $A^{\beta\,44}$ and IV $A^{\beta\,14}$.

This mountain has a gentle slope towards S.S.W.; the N.N.E. side is hollowed out, and receives the depression IV $A^{\beta\,78}$. It is 59 of Lohrmann's Sec. I.; he has given it a much bolder character than it possesses (see *ante*, p. 18).

81. A mountain-range W. of, and in union with, IV $A^{\beta\,70}$. Length of crest 10″·26, breadth of base at N. end 5″·31.

82. The valley between IV $A^{\beta\,70}$ and IV $A^{\beta\,81}$. Length 6″·25.

*83. A raised and nearly filled ring on the chain from the junction of *Ptolemæus* and *Alphonsus* towards *Sabine* and *Ritter*, N.N.W. of IV $A^{\beta\,81}$. Length 9″·79, aligns with the mountain IV $A^{\beta\,47}$ through *Horrox*; breadth 7″·64.

This ring is not given either by Lohrmann or by B. and M. It is certainly distinct on Rutherford's photogram, but may be overlooked among the mountains surrounding it; it is just within the line of circumvallation around IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$.

84. An elliptical crater between IV $A^{\beta\,83}$ and IV $A^{\beta\,70}$ in the angle formed by the junction of IV $A^{\beta\,81}$ and IV $A^{\beta\,83}$; length on a line passing through the N. angle of *Horrox* 6″·25, breadth 3″·17, mag. 0·28.

This crater, which is the seventh in order upon IV A^{β}, is not shown by B. & M. Lohrmann has *four* small craters W. of his plain 58, Sec. I., to which he alludes in his text; they are probably the valley IV $A^{\beta\,82}$, the crater

IV $A^{\beta\,84}$, the depression IV $A^{\beta\,85}$, and the W. slope of the mountain-peak IV $A^{\beta\,75}$, which appear best to answer to them.

85. A craterlet in the S.W. angle of IV $A^{\beta\,86}$; length N.W.–S.E. 3″·54, breadth 3″·17, mag. 0·20. It is the tenth in order upon area IV A^{β}.

86. The depression containing IV $A^{\beta\,74}$, IV $A^{\beta\,75}$, and IV $A^{\beta\,85}$.

87. The depression in which IV $A^{\beta\,81}$ and IV $A^{\beta\,82}$ are situated.

88. The plain E. of the depression IV $A^{\beta\,69}$ and N. of the valley IV $A^{\beta\,72}$, the E. part of Lohrmann's 58, Sec. I.

89. A "fault" of a minor character, which is traceable along the W. wall of the depression IV $A^{\beta\,86}$; it grazes the E. edge of the ring IV $A^{\beta\,83}$, passes along the N. part of the crest IV $A^{\beta\,81}$, through the valley IV $A^{\beta\,82}$, to a point westward of IV $A^{\eta\,8}$.

90. A hillock on the plain IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$.

91. A shallow depression on the plain IV $A^{\beta\,2}$ IV $A^{\gamma\,3}$.

92. A mountain-range between IV $A^{\eta\,13}$ and IV $A^{\beta\,70}$, N. end.

A large portion of this range lies in area IV A^{η}; length of crest 4″·01, breadth of base 8″·48.

93. A low mountain N. of IV $A^{\beta\,92}$; length of crest 9″·79.

94. A valley-like depression S. of IV $A^{\beta\,87}$; length 8″·48, breadth 4″·01.

95. A "cleft" from the S. angle of *Horrox* to the middle point of the E. border of IV $A^{\beta\,19}$.

This "cleft," which is visible on Rutherford's photogram, appears either to have broken through the S. border of *Horrox* or to have originated there; the almost rectilinear S.W. part of the rim of *Horrox* ends *abruptly* at the point where the "cleft" cuts it. The cleft has not affected IV $A^{\beta\,19}$, but reappears in the high land on its W. side, passes through the depression IV $A^{\beta\,71}$, and opens out beyond the mountain IV $A^{\beta\,35}$, the S. end of which is thrust forward in the direction of the line of "cleft" into the valley IV $A^{\beta\,72}$, and is traced still further between IV $A^{\beta\,83}$ and IV $A^{\beta\,85}$. The objects above specified are among the *faintest* on the moon's disk. If the surfaces E. and W. of the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$ *were continuous at the time of the production of the "cleft,"* and the "cleft," when formed, *cut through* the rim of *Horrox*, we might be able to infer that the date of *Horrox* was anterior to the dates of the "cleft," fault, and craters IV $A^{\beta\,19}$, IV $A^{\beta\,21}$, and that the period of upheaval of the high land forming the W. border of *Hipparchus* was posterior to the epoch of the production of the W. floor of *Hipparchus.* The character of IV $A^{\beta\,19}$, combined with the absence of any trace of the "cleft" upon the crater, strongly indicates the posteriority of IV $A^{\beta\,19}$; and this, taken in connexion with the probable recent date of the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$, tends to establish that the conformation of the features in this part of the lunar surface is of more recent origin than the system of "rays" from *Tycho.*

96(x). The western of two ridges on the interior W. slope of *Horrox.*

97. The eastern of two ridges on the interior W. slope of *Horrox.*

These ridges are inserted provisionally, having been observed but once. 96 was seen very satisfactorily on 1868, May 1^{d} 9^{h} 45^{m} with the Crossley equatorial of 7·3 in. aperture.

98. A cleft running from the N.E. border of IV $A^{\beta\,14}$ to the fault IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$, near IV $A^{\beta\,32}$.

99. A craterlet at the S. extremity of the buttress in the semicrater IV $A^{\beta\,53}$, discovered with the Crossley equatorial on May 2, 1868. It is the thirteenth in order on IV A^{β}.

II.—ADDITIONS TO AREAS IV A^{α}, IV A^{β}, AND IV A^{ζ}, WITH IDENTIFICATIONS OF OBJECTS IN THESE AREAS.

The requirements of selenographical research render it necessary that considerable attention should be given to the discovery of new objects not yet inserted in maps or catalogues, as well as the identification of those already recorded. If "fixity" is to be established or "change" detected, in either case it must be by constant and systematic observation, the only means by which the *invariable* character of an object may be ascertained and *apparent* changes eliminated, or by which it may be discovered that changes which seem to be only apparent are of such a nature as to lead to the suspicion, and, if well founded, the ultimate detection of *real* change. The objects recorded in Areas IV A^{α}, IV A^{β}, and IV A^{ζ} are mostly taken from Rutherford's photogram, 1865, March 6, and are consequently brought up to that date. In a few cases the dates are later. The identification of objects fixes their characters to the dates of observation, which in those of Areas IV A^{α} and IV A^{ζ} are mostly in the autumn of 1867. Those of IV A^{β} are in the spring of 1868, some being as late as November 5, 1868.

Additions to Catalogue.

Area IV A^{α}. The numbering of objects in this area in the printed catalogue extends to 88, the following have been added since.

89. A craterlet at the mouth of Lohrmann's valley, Sec. I. 87.

This craterlet is on the S.W. border of Reaumur, near the line of cliffs IV $A^{\alpha\,8}$.

90. A craterlet between IV $A^{\alpha 4}$ and IV $A^{\alpha\,16}$ nearest IV $A^{\alpha\,16}$. It was first seen with Mr. Barnes's silvered glass mirror on June 10, 1867.

91. The western interior slope of Reaumur.

92. A short mountain-chain S.E. of and nearly parallel with IV $A^{\alpha\,16}$.

93. A craterlet just E. of IV $A^{\alpha\,24}$, discovered by the Rev. W. O. Williams, 1867, October 17. Estimated at $2''{\cdot}0$; mag. 0·11.

94. The north part of an extensive depression between two low ridges, the western of which stretches northward from the mountain IV $A^{\zeta\,86}$ to the mountain IV $A^{\alpha\,28}$. The eastern in like manner extends from IV $A^{\zeta\,86}$ to the mountain-arm on which IV $A^{\zeta\,39}$ IV $A^{\alpha\,17}$ is situated. See IV $A^{\zeta\,122}$ *et seq.*, *post*, p. 40.

95. The north part of the western ridge.

96. A ridge just north of IV $A^{\alpha\,94}$, extending from IV $A^{\alpha\,7}$ to IV $A^{\alpha\,71}$.

The depression and ridges were discovered (1867, Dec. 23) on De La Rue's photogram, 1858, Feb. 22, by W. R. Birt.

97. A craterlet in IV $A^{\alpha\,58}$; diameter $3''{\cdot}17$, mag. 0·18.

98. A craterlet in IV $A^{\alpha\,58}$, N.N.E. of IV $A^{\alpha\,97}$; estimated diameter $1''{\cdot}5$, mag. 0·09.

99. A valley extending from IV $A^{\alpha\,59}$ to 1° S. lat. between IV $A^{\alpha\,43}$ and IV $A^{\alpha\,58}$.

The dotted line on Area IV A^{α}, between the crest of IV $A^{\alpha\,43}$ and the W. side of the valley IV $A^{\alpha\,58}$, I find on Rutherford's photogram to be a subordinate ridge on the slope upwards to the W. side of the valley IV $A^{\alpha\,58}$.

100. A cleft at the W. foot of IV $A^{\alpha\,43}$.

This cleft was discovered by Mr. G. J. Walker of Teignmouth. Writing under date of 1868, Feb. 1, he says, "The lower part of IV $A^{\alpha\,43}$, or the foot of the ridge, always looks to me like a sort of continuation of the cleft IV $A^{\alpha\,47}$, or like a long ravine communicating with it."

101. A shallow valley between IV $A^{\alpha\,4}$ and IV $A^{\alpha\,43}$, S. of IV $A^{\alpha\,58}$.

It is of a curved form; the S.W. end bisects a line drawn from the S. end of IV $A^{\alpha\,43}$ to the W. side of IV $A^{\alpha\,4}$.

IV $A^{\alpha\,99}$, IV $A^{\alpha\,100}$, and IV $A^{\alpha\,101}$ were first seen by Mr. Walker; they are all on Rutherford's photogram, 1865, March 6.

102. A depression of a semicircular form on the mountain-range forming the east border of Hipparchus, the northern part. It is in this depression that the crater IV $A^{\alpha\,17}$ IV $A^{\zeta\,39}$ is situated (see IV $A^{\zeta\,126}$, *post*, p. 40).

103. A short spur on the S.W. side of IV $A^{\alpha\,15}$, near IV $A^{\alpha\,40}$.

This spur is not numbered on the map. It was recognized by Mr. G. J. Walker of Teignmouth, who thus mentions it under date of March 30, 1868:—"The space numbered 15 in the map was dark, whilst the two ridges 40 and the nearer shorter one appeared. In the middle of 15 [Query, the spur next to Rhæticus, see 105] there was a spot of light indicating a lower ridge."

104. An oval space (Mr. Walker queries it as a crater), not numbered in the map, but shown lying in the angle between the lines of fault IV $A^{\alpha\,72}$ and IV $A^{\alpha\,49}$ on the S.W. of Rhæticus.

105. A short spur on the S.W. side of IV $A^{\alpha\,15}$, close to the S. end of Rhæticus (see note on 103).

106. The west wall of Rhæticus.

Additions to Area IV A^{β}.

IV A^{β} 100. A craterlet on the S.E. boundary of Lohrmann's 58, Sec. I., S.W. of IV $A^{\beta\,64}$.

101. A craterlet on the S.E. boundary of Lohrmann's 58, Sec. I., S.W. of IV $A^{\beta\,100}$.

These craterlets were seen with the Crossley equatorial, 7·3 inches aperture, power 122, on May 28, 9.15 to 10.30. They were seen by glimpses only, the atmosphere being hazy and somewhat unsteady.

102. A craterlet? S. of IV $A^{\beta\,3}$, seen as a white spot with the Crossley equatorial, 7·3 inches aperture, power 122, on May 1, 1868, and probably seen as a craterlet with the Royal Astronomical Society's Sheepshanks telescope No. 5, power 100, on May 30, 1868.

103. The north part of the formation between the faults IV $A^{\eta\,35}$ IV $A^{\beta\,63}$, —IV $A^{\eta\,11}$ IV $A^{\beta\,20}$ IV $A^{\alpha\,72}$,—IV $A^{\eta\,23}$ IV $A^{\beta\,62}$.

104. The gorge between IV $A^{\beta\,39}$ and IV $A^{\beta\,4}$.

105. The mountain-crest between IV $A^{\beta\,49}$ and IV $A^{\beta\,59}$.

Additions to Area IV A^{ζ}.

IV A^{ζ} 115. A depression or crater N. of IV $A^{\zeta\,14}$ and IV $A^{\zeta\,15}$; estimated diameter $2''\cdot0$, mag. 0·12.

It is recorded as sketched on map 1867, April 11, and was afterwards seen 1867, May 11, with the Royal Society's $4\frac{1}{4}$-inch achromatic, power 230. It is shown by B. & M.

The Rev. W. O. Williams ascertained in October 1867 that the mountain-range IV $A^{\zeta\,48}$ presented the form of a stem with two branches in the form of a "fork." Restricting the designation IV $A^{\zeta\,48}$ to the northern part or stem, we have:—

116. The east branch of IV $A^{\zeta\,48}$ from the fork.

117. The west branch of IV $A^{\zeta\,48}$ from the fork.

118. The valley between IV $A^{\zeta\,116}$ and IV $A^{\zeta\,117}$.

These objects were discovered independently by the Rev. W. O. Williams and Herbert Ingall, Esq., on October 18, 1867.

119. The depressed surface between IV $A^{\zeta\,1}$ and IV $A^{\zeta\,6}$, with which the valley IV $A^{\zeta\,85}$ communicates.

Mr. Grover (1867, Nov. 5) describes the opening from the valley as sloping to a point about halfway between IV Aζ^{61} and IV Aζ^{37} on the N.W., and IV Aζ^{1} on the S.E. This depression is very marked in the photograms.

120. A ridge forming the W. side of the valley IV Aζ^{96}, discovered by the Rev. W. O. Williams, 1867, Nov. 15.

121. A craterlet N. of IV Aζ^{13}, discovered by the Rev. W. O. Williams, 1867, Oct. 18.

IV Aζ^{115} and IV Aζ^{121} are shown on Rutherford's photogram.

122. A large depression between two low ridges, viz.,

123. The east ridge, and

124. The west ridge.

The following objects occur on IV Aζ^{123}, viz. IV A$^{\alpha\,17}$, IV Aζ^{39}, and IV Aζ^{112}.

The following objects occur on IV Aζ^{124}, viz. IV A$^{\alpha\,71}$ and IV Aζ^{102}.

Both ridges converge to the mountain IV Aζ^{86}.

For the northern portions of the depression and ridges see IV A$^{\alpha\,91}$ to IV A$^{\alpha\,96}$, *ante* p. 38.

125. A ridge between IV Aζ^{59} and IV Aζ^{115}.

This ridge was identified by the Rev. W. O. Williams, 1868, Jan. 2.

126. The S. part of the depression in which IV A$^{\alpha\,17}$ IV Aζ^{39} is situated (see IV A$^{\alpha\,102}$, *ante* p. 39).

Identifications.

The identifications of objects are arranged in subzones, as being the most convenient for comparison with the sequence of objects in each. (See Report, 1866, pp. 241, 242, and *ante*, pp. 14, 15.)

The small index figures, as 63^2, indicate that the object has been identified by as many observers, in this instance by two.

Zone II.

Subzone No. 2.	Lat. 0° to 2° S.	Area IV A$^{\alpha}$	15, 40, 43, 47, 58, 63^2, 65^2, 72, 86^2, 87.
		Area IV A$^{\beta}$	1^{2}*, 2^2, 3^2, 4^2, 10^2, 11^2, 12^2, 13, 20, 29^2, 39^2, 40^2†, 43^2, 44^2, 45^2, 46, 52, 53^2, 78^2.
Subzone No. 4.	Lat. 2° to 4° S.	Area IV A$^{\alpha}$	4^2, 16, 41.
		Area IV A$^{\beta}$	14, 15, 16, 18, 20, 30, 31, 47, 96.
Subzone No. 6.	Lat. 4° to 5° S.	Area IV A$^{\alpha}$	6, 7^2, 9, 18, 22, 23, 24^2, 28, 51, 71^3, 76.
		Area IV A$^{\beta}$	19, 21, 22, 35, 38.

Zone IV.

Subzone No. 2.	Lat. 5° to 7° S.	Area IV Aζ	24^2, 37, 39^3‡, 47^3, 49^3, 58^2, 96, 103, 104, 105, 106, 108, 109, 110, 111, 112, 113, 114.

* IV A$^{\beta\,1}$. Mr. Walker appears (1868, Sept. 7) to have obtained a glimpse of the difficult objects IV A$^{\beta\,5,\,6,\,7,\,8,}$ and ^{9} on this mountain-range, but he could not distinguish them as separate peaks or count them; the mountain-range he describes as having a serrated edge, like hillocks close together. Oct. 7, 1868, he found 4 or 5.

† IV A$^{\beta\,10}$, 1868, May 4. The colour of this depression was a dark grey, probably the darkest in the immediate locality. It is recorded as 2°·5, IV A$^{\alpha\,47}$ being 1°·5.

‡ IV A$^{\alpha\,17}$ IV Aζ^{39}. This object is variable, sometimes appearing as a crater, at others as a white spot. With high illuminations *two* spots have been seen (see *ante*, p. 29). 1868, April 4, Mr. Baxendell discovered a small crater on the site of the eastern spot, which is not yet inserted in the catalogue, as its exact locality is undetermined.

Subzone No. 4. Lat. 7° to 9° S. Area IV A ς 1^3, 3, 4^4, 5^4, 6^2, 7^2, 8^2, 9^2, 13^4, 14^4, 15^4, 18^4, 19^4, 21, 22, 43^2, 44, 45, 48^3, 61, 71, 77^2, 95, 107^2, 115^2, 121.
Subzone No. 6. Lat. 9° to 10° S. Area IV A ς 34, 50, 51, 53, 12^2.

The lunar objects to which the above designating numbers in each area are appended have been examined since the construction of the maps of the areas, and may be regarded as testifying to the character of each object as it existed at the time of examination, which in most cases agree with the description in the catalogue.

III.—LINNÉ.

Observations of this object continue to be made by gentlemen in concert with the Committee. In the last Report (Report, 1867, pp. 3 to 24) three essential features were described, viz. a large shallow crater, containing within it a small crater, both being replaced by a large ill-defined white spot under an increase of solar altitude. On the 26th of June 1868 *Linné* was observed under very favourable circumstances by Messrs. Huggins, Penrose, Birt, Webb, Carpenter, Joynson, and Williams, from 8.30 to 11.30 G.M.T. During the earlier observations nothing was seen but a small cone, which cast a shadow to the east. This cone was not situated upon a ridge, the sixth of Schröter, as he states his spot *v* to be (see *post*, p. 44, and Report, 1867, p. 4), but appeared as if isolated, standing upon a slightly raised portion of the *Mare Serenitatis*, having Schröter's sixth ridge to the south, the cone being in the line of prolongation of this ridge to the north. On the west a curvilinear ridge of lower altitude (given by Beer and Mädler) was seen, from the east foot of which the surface rose very slightly to the base of the cone. There was not the slightest indication of a shallow crater, nor was there the least appearance in the surface around the cone which might be considered indicative of its becoming a white spot, as the sun rose above it. The terminator was a little east of the cone, and the next ridge beyond the cone towards the east was becoming visible.

Mr. Carpenter was the only observer who saw on the cone the crater-opening. From the drawings and descriptions of this object, it would appear to be very similar to a terrestrial volcanic cone, the eastern side being broken down. Messrs. Joynson and Williams record the cone as "a bright point," an appearance it would present in telescopes of smaller aperture than those in which it was seen as a cone with crater-opening.

During the earlier period of the observations the altitude of the sun was less than 1°, but as it became higher a change was observed, which will be described presently. The great importance of determining the true nature of this change is obvious. Was it actual, or was it optical? So far as the observations from 1866 (Oct. 16) to 1868 (Sept. 7) testify, this change takes place, more or less constantly, with *low* solar altitudes (see *post*, p. 45, points of contrast 7th and 8th). It is consequently of importance to ascertain by future observation whether the transition from the visibility of the lunar surface to that of a white spot, by or in which the character of the surface is no longer rendered apparent, is constant for solar altitudes and azimuths of the same value. If the change be purely optical and dependent upon the two conditions following, viz. the nature of the lunar surface on the one hand, and the incidence of the solar rays on the other, as soon as the sun attains the requisite altitude and azimuth, the altered appearance

supervenes; but if the surface itself should at any time be altered so that with the same incidence of the sun's rays the former altered appearance should be no longer observed, the change, of whatever nature it may be, could not in that case be referred to a purely optical source, some *real* change, either of a temporary or lasting character, must have transpired. While the change about to be described is constant for constant solar altitudes and azimuths, the question whether it is purely optical, or whether it is connected with a temporary but real diurnal change cannot be resolved; but as soon as the character of the surface, as seen at sunrise and sunset, is also clearly perceptible with solar altitudes *higher* than those at which the white spot now appears and disappears, the phenomenon is at once removed from the category of optical to that of real change,—it may be temporary as referred to the luni-solar day, or of a more lasting nature if the surface itself should undergo a physical change. This will to a great extent preclude the expression of opinion, which is generally founded more or less on insufficient evidence; observation alone can guide us to a safe conclusion in connexion with the questions raised on *Linné*. While refraining from expressing an opinion, we ought not to relax in collecting, arranging, and discussing evidence, as the only means by which we can obtain such an acquaintance with the phenomena of the moon's surface as may enable us finally to dispose of such questions as are at present agitated respecting them. The change above alluded to is best elucidated by the following records of observation.

The first notice of change occurs in the following extracts from Mr. Birt's note-book:—

"10.30. During the last half-hour a decided change has occurred in the appearance of *Linné* * * * The cone is no longer visible, nor the shadow, but a somewhat bright white spot, larger than I $E^{\gamma\,3}$ [the southern of the three craters to the N.W.], and nearly as large as I $E^{\theta\,1}$" [the middle of the three craters].

I have received from Mr. Gorton a drawing of *Linné* made by Mr. Williams of Liverpool, on the evening of June 26, at 11 P.M., in which *Linné* is represented as a white spot. This differs so very materially from the earlier observations that a correspondence ensued, of which the following is the result:—

"Although the drawings [Mr. Huggins's, Mr. Carpenter's, and Mr. Williams's] were made on the same evening, and differ amongst themselves, there does not appear to be any contradiction. Some observers saw the cone, another the opening, and others the bright white spot, the formation of which appears to have been actually witnessed. Mr. Joynson places the observations of Mr. Birt and those of Mr. Williams in conjunction with his own in juxtaposition, thus:—

1868.		Mr. Birt reports.	Messrs. Joynson & Williams report.
June 26,	10.0	Cone-shadow well marked.	A bright point.
	10.30	Cone disappeared; a somewhat bright white spot.	Spot duller and flatter.
	10.45 to 11.30		Spot as drawn [*i. e.* the ordinary white spot]. Moon low."

Mr. Joynson adds, "I think it is quite clear that the cone or bright point gradually took the aspect of a spot, and as it enlarged it became duller and flatter."

The transition, to which allusion has been made, was seen on the evening of the 26th of June by three observers.

The next favourable opportunity for seeing *Linné* near the terminator occurred on the 24th of August 1868. The following is a record of observations by Mr. Walker, of Teignmouth :—

"1868, August 24^{d} 7^{h} 45^{m}. *Linné*: crater on the top of a gently rising ground (conical shape), wall to right (east) in stronger illumination; below to left appearance of depression. Definition good. Could not make out any thing inside the crater; crater looked clean; no appearance of white cloud or haze."

Subsequently Mr. Walker furnished the following explanation :—

"The gently rising ground I spoke of was exterior to *Linné*, nothing of the interior or floor of which was visible, the illumination not being yet high enough. By a conical shape (not a well-chosen phrase) I meant that the ground rose in all directions around *Linné*, which thus presented the aspect of a shallow crater on the summit of a rising ground. The impression of shallowness was conveyed by the thinness of the illuminated circuit of the crater, and I think also by the shade of darkness of the interior of the crater. Of the cone I saw nothing."

Mr. Walker's observation very fairly agrees with those made on June 26. The rising ground appears to be the surface between the ridges upon which the cone or crater is situated. Mr. Walker speaks of the *thinness* of the circuit [*Qy.* rim] of the crater, from which he inferred that it was *shallow*; he is decisive upon the absence of the white cloud or spot.

Under the evening-illumination of the same luni-solar day, on Sept. 7, 1868, 11.30 to 12.0 L.M.T., Maresfield, Sussex, Capt. Noble recorded the following observation :—

"With powers of 154, 255, and 394, Linné, which is now tolerably near the terminator, suggests the idea of being a mammillariform object. I sometimes seem to glimpse a darker (though by no means black) spot near the middle of it, giving it the aspect of a thick ring; but as the shading is in the opposite side to the sun, and is moreover faint, it is just possible that it may be the result of the convexity of this wonderful object."

Two hours later, viz. Sept. 7, 1868, 14^{h}, Mr. Walker, of Teignmouth, recorded as follows :—

"Eudoxus on terminator. *Linné.* Hill on east side of the crater bright. Crater dark inside. Curved ridge, N.W. cut by the terminator. Two other ridges S., the east one sweeping up to Sulpicius Gallus, which was very marked, round, and has higher walls than *Linné*, which is rather the larger perhaps of the two, and oval-shaped. Fancied the hill or elevated portion of the crater E. had a crater on it."

Mr. Walker's observation is accompanied by a sketch, from which it appears that the portion designated as the crater is the surface between the ridges, the rising ground of the morning illumination, and that the hill on the east is the cone on which Mr. Walker thought he saw a crater (the crater-opening); this hill occupies the precise position of the cone in the observations of June 26.

The observations of Mr. Walker and Capt. Noble, on Sept. 7, bear the same relation to each other as the earlier observations on June 26 do to the observation of Messrs. Joynson and Williams on the same evening. In one case we have the topographical features of the district near *Linné* replaced by the white spot; in the other the white spot is first seen, but in a short time it has disappeared, and the features of the district have become visible.

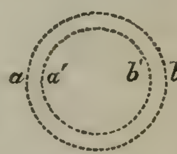
The change to and from the white spot in each case is well marked; and it now remains to ascertain if this change always takes place with the same solar altitudes and azimuths. To observe the topographical features and witness the transition, it is necessary that *Linné* should be very near the terminator.

Herr von Mädlor has obligingly communicated the following memorandum respecting *Linné*:—

"The insrument I made use of to produce drawings of the moon was a refractor of $3\frac{3}{4}$ feet of focal length and 43 lines of aperture. Commonly I employed a magnifying-power of 300, but the trigonometrical measurements have been executed with a magnifying-power of 120, which allowed me to reach to the edge of the moon."

"Respecting the crater *Linné*, it was a principal point in my trigonometrical network, and consequently I have observed it very often.

"I remember that this crater did occupy the greatest part of the diameter of the circular wall, so that if $a\ b$ extended over 1·4 German mile (6·4 English), $a'\ b'$ was at least 0·9.



"I have never seen any real change, only optical ones.

"Only in or near the full moon it was a white spot, almost as white in the middle as on the edges; these edges were not wholly distinct, but always circular and fit for measurement.

"The deepness of the crater must have been considerable; for I have found an interior shadow when the sun had attained an altitude of 30°. I have never seen a central mountain in the interior.

(Signed) "MÄDLER."

Without expressing the slightest opinion on the questions of change or fixity derived from a comparison of the above with recent observations, it may be permissible to notice the points of contrast between the earlier and more recent observations of *Linné* which the statements of the Baron Mädler afford. Such a comparison and contrast is essential if we desire to arrive at a true conclusion. The following appear to be the most important.

Points of contrast between earlier delineations and recent observations of the lunar crater *Linné*:—

1st. The earliest authentic delineations and records of *Linné* represent this object as a crater, assign to it a diameter of about six English miles, and speak of it as being very deep.

2nd. Recent observations, *i. e.* from 1866, Oct. 16, to 1868, Sept. 7, are decisive as to the existence of a small cone, with crater-opening on the portion of the *Mare Serenitatis* surrounded by ridges.

3rd. It has been assumed that the white spot v in Schröter's Tafel ix. represents *Linné* as seen on Nov. 5, 1788, and that its present state is nearly similar.

4th. Capt. Noble pointed out, at a Meeting of the Royal Astronomical Society, that a line drawn from *Plinius* through *Bessel* will fall on *Linné*. This line on Schröter's drawing falls very nearly on the dark spot, which is very unlike the appearance of *Linné* at present.

5th. Herr von Mädler has very recently recorded that in 1831 the crater-opening occupied 0·9 of the diameter of the external wall, which measured about 6·4 miles English.

6th. The diameter of the base of the cone recently observed is less than three English miles, and the crater-opening still smaller.

7th. In the year 1831 (*authority* Herr von Mädler) the white spot was seen only near the time of full moon, *almost* as white in the middle as at the edges.

8th. In the years 1867 and 1868 the white spot appeared shortly after sunrise and disappeared a little before sunset, and was frequently observed to have a *brighter* nucleus, instead of being almost as white in the middle as at the edges.

9th. In the year 1831 (*authority* Herr von Mädler) the interior shadow was perceptible until the sun attained an altitude of 30°.

10th. In the years 1867 and1868 the small crater-opening has been seen as a small black spot, rather west of the centre of the white spot, long after the terminator has passed *Linné*, but the usual interior crater-shadow has not been seen except with comparative low solar altitudes.

Fourth Report of the Committee for Exploring Kent's Cavern, Devonshire. The Committee consisting of Sir CHARLES LYELL, *Bart.*, Professor PHILLIPS, Sir JOHN LUBBOCK, *Bart.*, Mr. JOHN EVANS, Mr. EDWARD VIVIAN, Mr. GEORGE BUSK, *and* Mr. WILLIAM PENGELLY (Reporter).

IN their Third Report, presented to the Association in 1867, the Committee stated that the Cavern consists of two parallel series of chambers and galleries, having, approximately, a north and south direction; that their researches had been confined to the Eastern Series, in which the North-east Gallery, the Vestibule, the Passage of Urns, the Great Chamber, and the Gallery had been completely explored to the depth of 4 feet below the base of the Stalagmitic Floor; that the investigation of the Lecture Hall had been begun, but that the greater part of it, as well as the entire South-western Chamber and the North and South "Sally Ports," remained untouched.

The year 1867–68 has been devoted to the Lecture Hall and South-west Chamber. The exploration of the former has been completed, and, so far as an estimate can at present be formed, the latter will have been thoroughly investigated in about two months from the present time. There is, however, some uncertainty on this question, since the further end of this Chamber is now closed with an enormous accumulation of stalagmite; and it is not improbable that when this is removed the apartment may prove to be much larger than is at present supposed. The Superintendents of the work incline to the opinion that a gallery will sooner or later be laid open here, which will lead into the Western Series of Chambers and Galleries. There is at present but one known channel of communication between the two series—that leading westward out of the Vestibule, near the opposite or northern end of the Cavern.

The Committee continue to follow the mode of exploration laid down at the commencement of the work, and described in detail in their First Report, presented in 1865. The deposits are excavated in successive foot-parallels, and each parallel is removed in foot-levels, to the depth of 4 feet beneath the lower surface of the Stalagmitic Floor. In no instance has anything like a continuous limestone bottom of the Cavern been reached; but a depth greater than 4 feet would be incompatible with convenient, economical, trustworthy working, as it would be necessary to be continually putting up and

taking down scaffolding or working-platforms, and there would be a great liability for the deposit to "cave in," which, by rendering it impossible to determine their exact positions and associations, would deprive the objects found of much of their interest, as well as of their value as evidence.

The workmen still follow the practice of first examining the deposits *in situ,* and of re-examining them by daylight at the entrance of the Cavern; the lines described in the First Report (1865) are still employed in order to fix the precise position of every object found; the specimens, as at the beginning, are all carefully cleaned and labelled, those found in each "yard" (mass of deposit a yard long and a foot square in the section) are kept together in a separate box; the Cavern is visited daily by the Superintendents; the Secretary continues to keep a daily journal of the work; Reports, signed by both Superintendents, are, at the end of each month, forwarded to Sir C. Lyell, Chairman of the Committee; and well-defined and satisfactory arrangements exist for the admission of visitors accompanied by the Superintendents, so as at once to keep alive a healthy interest in the exploration and to prevent inconvenience from their visits.

Amongst the numerous visitors during the past year, the Superintendents had the pleasure of receiving Dr. Hooker, President of the British Association.

The Lecture Hall.—In their Third Report (1867), the Committee stated that researches, probably on a somewhat large scale, had been carried on in the Lecture Hall by Mr. M'Enery and the other early explorers, who, instead of taking out of the Cavern that portion of the deposits which they had examined, simply threw it on one side. On the removal of this dislodged material, the Committee found that they had considerably over-estimated the extent of the old working, and that by far the greater portion of the deposits in this Hall remained indubitably intact.

The objects met with, not only in the broken ground, but in every locality about which there was the least uncertainty, were carefully kept distinct from those found in undoubted virgin soil.

Without at present entering into details, it may be stated that in the Lecture Hall the deposits were of the same general character and order as in those parts of the Cavern which the Committee had previously explored and reported on,—Red Cave-earth of unknown depth, completely sealed up with a Stalagmitic Floor, which, in its turn, was covered with a layer of Black Mould.

The objects found in the overlying Black Mould were less numerous than, but similar to, those described from the same accumulation in former Reports. Amongst them may be mentioned several pieces of pottery, a spindle-whorl, a roughly shapen piece of New Red Sandstone, a portion of a bone comb, part of a small vase, a small red earthenware pan, marine shells, a small piece of smelted copper, the entire lower jaw and an almost complete skull of a badger, part of a human upper jaw with eight teeth, of which four are still in their sockets, and the internal cast of a fossil shell.

The potsherds do not require detailed description, most of them are of black coarse clay mixed with small stones, some of them are ornamented, whilst others are plain, and, in short, they closely resemble those described in the former Reports.

The spindle-whorl is of clay-slate, measures an inch in diameter and half an inch in depth, and is ornamented with a series of curvilineal and straight lines, both on its curved and flat surfaces. It is, perhaps, worthy of remark that, though the Cavern has yielded spindle-whorls formed of different kinds

of stone, the best made, the most highly finished, and the only ornamented specimens are fashioned in slate.

The piece of red sandstone was perhaps a spindle-whorl marred in the making. Good specimens formed of the same material have been found in the Cavern in previous years. It is rudely of the required form, about the size of a rather large whorl, but is imperforate.

But for the more or less perfect specimens found in former years, it would not have been easy perhaps to identify the fragment of bone comb. It is but a portion of what may be called the shaft, both ends having been broken off. It must have been of the same type as those described in previous Reports, all of which had their teeth at one end; but it differs from all those found before in being ornamented with well-drilled, small, circular punctures, which traverse the shaft obliquely in two parallel series, the direction of one set being at right angles to that of the other.

The red earthenware vessel is no doubt a pan of the kind used for flower-pots to stand in, and is clearly modern.

The marine shells are chiefly those of the Oyster, Cockle, and Pecten. One of the last has, near its anterior margin, a small elliptical hole, which is probably artificial.

The human jaw and teeth may be comparatively modern. They were submitted to Messrs. Rodway, the eminent dentists of Torquay, who stated that "several of the alveoli possessed peculiar irregularities, which confirm other unmistakeable evidence that the whole of the teeth belonged to the same individual; that the loose teeth were considerably worn away, particularly the canine, at the end of which is exostosis, which was caused by the whole, or the greater part, of the mastication of later years being performed by the canine; that they were the teeth of an old person, probably a man; and that they would be likely or certain to preserve their freshness of aspect for an indefinite period."

The cast of the fossil shell is apparently from the Oolite, and was perhaps lost in the Cavern by some geological tourist just arrived from the neighbouring Jurassic district of Dorsetshire.

With the exception of the ground broken by the early explorers, which has been already mentioned, the Stalagmitic Floor was everywhere continuous. It varied from 2 to 32 inches in thickness, but rarely measured less, and commonly more, than 6 inches. It was generally of granular structure, but occasionally crystalline, and sometimes made up of alternate crystalline and granular layers. It contained numerous blocks of limestone and of old stalagmite; the former had no doubt fallen from the roof from time to time, and some of them measured as much as 4 feet in length. In addition to such as were completely incorporated in the Floor, there were many, as in other branches of the Cavern, which were lodged in and rose above it, whilst others projected from it downwards into the Cave-earth.

The imbedded masses of stalagmite were invariably of a structure unlike that of the floor in which they were lodged. In all cases, they were, at once, finely laminated and highly crystalline, the latter character being displayed in a columnar or fibrous structure at right angles to the laminæ, whether the latter were plane or curvilinear. In some cases, these blocks, like those of limestone just mentioned, projected above or below the Floor into the Black Mould or Cave-earth respectively, whilst others were completely invested. It cannot be doubted that they were fragments of an older Floor, which, as stated in previous Reports, and especially the third (1867), had been at least partially broken up at a comparatively early period in the

Cavern's history. It will be convenient thereforeto speak, in future, of the floor represented by these blocks as "The Older Floor," and of that which the Committee found spreading in an unbroken sheet through all branches of the Cavern as "The Modern Floor."

As in former years, bones were occasionally found in the Modern Floor of Stalagmite in the Lecture Hall. Amongst the most important are a fine molar of Rhinoceros, a premolar of Hyæna, two or three molars of Bear, a large part of a humerus, probably of Bear, and an *os calcis* of some large animal.

The teeth of Rhinoceros and Hyæna were found, in the presence of one of the Superintendents, September 21, 1867, lying together very little below the upper surface of the Stalagmite. Since the times of *Rhinoceros tichorhinus* and *Hyæna spelæa* in Devonshire, therefore, the increase of thickness of the Stalagmitic Floor, in that particular part of the Cavern, has been barely sufficient to cover these interesting relics.

A few examples of charred wood were found in the same Floor.

In most cases, the composition of the Cave-earth was of the ordinary typical character—about equal parts of red loam or clay, and of comparatively small angular fragments of limestone. In this condition it almost invariably contained bones, but when there was any marked departure from it, by either loam or stones being greatly in excess, bones were extremely rare. In a few instances, the deposit was a mixture of fine earth and sand, resembling ordinary road-washing, and contained no trace of bone.

The Cave-earth contained a considerable number of fragments of Devonian grit, huge blocks of limestone, large masses of old stalagmite, and loose lumps of rock-like breccia.

The grit fragments could not have been derived from the Cavern-hill, but were probably furnished by neighbouring loftier eminences. They have assumed subangular or well-rounded forms indicative of the rolling action of water, but their transportation into the Cavern by this agency would require that the district should have a surface-configuration very unlike that which now obtains.

In addition to the grit pebbles, there were found mingled with them subangular and rounded pieces of quartz and flint, and also a small angular piece of crystalline schist, such as is not found in any part of the Torbay district, but is characteristic of the southern angle of Devonshire, or what may be called the Start and Bolt district. A pebble believed to have been derived from the same locality was mentioned in the Second Report (1866).

The blocks of limestone occurred at all levels in the deposit; they were all quite angular, and some of them many tons in weight.

The masses of old stalagmite were of the same structure as those in the Modern Floor, and were found everywhere in the Cave-earth; they were all in the form of huge cuboidal blocks, with sharp unrounded edges. The Older Floor, of which they are obviously remnants, appears to have been broken up by being fractured along planes at right and other high angles to its upper and lower surfaces. There appears to have been no instance of division in planes even distantly approaching parallelism to these surfaces. Many of them contained teeth and bones, all, so far as they were identified, the remains of the Cave-bear.

The loose lumps of rock-like breccia were of a more or less rounded form, and were composed of red earth, angular pieces of limestone, and rounded and subangular pieces of Devonian grit; they differed from the Cave-earth in being invariably cemented together like a firm mass of concrete, and in containing a considerably greater proportion of fragments of grit. Almost

all of them were crowded with teeth and bones, which, so far as is known, are those of the Cave-bear. No teeth-marks have been detected on any of them, nor were there any traces of fæcal matter. Many of the canines and molars were of great size, and some of the former were so much worn as to suggest that they had belonged to old animals whose molars had become incapable of performing their functions.

These lumps of breccia had not the appearance of being portions of the ordinary Cave-earth agglomerated *in situ*. Their aspect was rather that of remnants of a deposit older than that in which they were incorporated,—the deposit, in fact, which the Older Floor of Stalagmite had covered, and on which it had been formed. To a large extent, this opinion received confirmation in the fact, already mentioned, that the osseous remains in the lumps of breccia as well as in the blocks of old stalagmite were, at least mainly, those of the Cave-bear, the other members of the Cave-fauna being unrepresented.

The Cave-earth in the Lecture Hall contained teeth of Horse, Rhinoceros, Hyæna, Bear, Fox, Deer, Mammoth, Lion, Ox, and Badger; their prevalence being indicated by the order in which their names are given, those of the Horse being the most, and of the Badger the least abundant. The teeth were accompanied by a considerable number of bones, many of which were deeply scored with teeth-marks, others were split longitudinally, and several were invested with thin films of stalagmite, irrespective of the depth at which they were found. These different conditions of the bones are interesting and significant,—the first implying the presence of the living hyæna, the second the operations of man, and the last the slow and intermittent accumulation of the Cave-earth, since each bone must have lain on what was the *upper* surface of the deposit for a considerable period, during which it was exposed to the action of the lime-laden drip from the roof of the Cavern.

The statement, in the Third Report (1867), that fæcal matter was met with almost exclusively in the Great Chamber, requires considerable modification. During the year 1867–68 a greater quantity of this material was found in the Cave-earth, in the Lecture Hall, than had been met with previously in the adjacent Chamber just spoken of; it occurred at all levels, and sometimes in masses a foot high. Occasionally individual coprolites were encountered which had undergone no change either of place or of form since they were originally dropped by the hyæna—a fact which goes far to show that the Cave-earth was neither all introduced at one and the same time, nor by violent agency, such as a great rush of water.

This branch of the Cavern was not very productive of flint tools, or, with the exception of split bones, other evidences of human existence. Omitting mere chips and doubtful flakes, it yielded no more than five implements, all of which are very inferior to the fine specimens discovered in former years. Two of them were found in the first foot-level, two in the second, and one in the third. One of them is formed of grey cherty flint, of a kind which the old men of Kent's Hole frequently employed; the others are of a finer variety, and of the prevalent white colour. They all belong to the *Lanceolate* type of implement. The best of the series is that composed of chert; it was found in the first or uppermost foot-level, October 18th, 1867. Its point had been broken off before it was met with. At present it measures 2·8 inches in length, and 1·3 inch in greatest breadth. There does not appear to have been much skilled labour expended on it, and its edges are considerably broken.

South-west Chamber.—The "Lecture Hall" opens on its south-western

side into an apartment, which, on account of its position in relation to the other branches of the Eastern Series, has been termed the "South-west Chamber." It is at present comparatively small, but, as has been already remarked, it may prove when completely emptied to be much larger. At the junction of the two apartments, the space between the opposite walls of the Cavern is inconsiderable; and this, before the workmen commenced their excavations, was much diminished by an enormous mass of limestone which had fallen from above, and was estimated at upwards of 100 tons. Its base was buried from two to three feet deep in the Cave-earth, and its summit reached a height of fully six feet above the Modern Floor of Stalagmite. On account of its form it was commonly known as the "Pulpit Rock," but it not unfrequently received the appellation of the "Lecturer's Rostrum," mainly because, when lectures were delivered within the Cavern on its history and formation, the speaker always took his stand on this rock, his audience being assembled in the adjacent Lecture Hall. The removal of the Pulpit absorbed a considerable amount of time, but it was quite indispensable in order to the excavation of the South-west Chamber, the entrance of which it guarded.

In the South-west Chamber there was no trace of the overlying Black Mould. This accumulation had presented itself in every other branch of the Eastern Series of chambers and galleries, with the single exception of the inner portion of the Gallery in the western wall of the Great Chamber, where it gradually thinned out. It covered the entire Floor of the Lecture Hall to a depth as great as in any other part of the Cavern, but it terminated abruptly at the Pulpit Rock, and was not resumed southwards.

In 1846, a Subcommittee of the Torquay Natural-History Society, consisting of Dr. Battersby and the Superintendents of the present work, commenced a search in this Chamber, when they broke up the Modern Floor of Stalagmite over a rudely circular area about 6 feet in diameter. They excavated the underlying Cave-earth to the depth of about 2 feet, when, having found nothing, they abandoned the search, leaving the pit empty and the materials dug out of it lying in a heap near. Probably no part of the Cavern is in wet weather more exposed to drip than this; hence it might have been expected that here, if anywhere, twenty-two years would have produced a film of stalagmite of appreciable thickness, especially as it was known that the Modern Floor attains an average thickness considerably surpassing that in any other part of the Cavern which the Committee have explored. Yet not a film was to be found either at the bottom of the pit, on the section made in digging it, or on the Cave-earth thrown out of it. This remote part of the Cavern was very rarely entered by visitors, and the operations of nature went on without check or interference; but everything was found precisely as it was left upwards of twenty years ago.

The form of the South-west Chamber, as well as the huge accumulation of stalagmite on its western side, rendered it expedient to excavate the deposits it contained in two distinct "Divisions" or series of workings—an eastern and a western, the working direction in the former being southward, and in the latter westward. The first has been completed, and considerable progress has been made in the second.

With the exception of the ground broken by the Torquay Natural-History Society, the Modern Floor of Stalagmite was everywhere perfectly continuous throughout this Chamber. In the Eastern Division it averaged 28 inches in thickness; in one instance only it was no more than 6 inches; it was very seldom so little as a foot, and it several times attained to 5 and even

6 feet. In its structure it was commonly granular, except at and near its junction with the walls of the Cavern, where it frequently consisted of thin crystalline laminæ, and was extremely hard and tough. Numerous angular masses of limestone were found in it, and some of them were of great size; but there were no incorporated blocks of old stalagmite.

In the northernmost or first eight foot-parallels in this Division, the Cave-earth occupied each entire section, from the bottom of the Modern Stalagmitic Floor to the base of the lowest or fourth foot-level. It was of the ordinary type, and, like that in every other branch of the Cavern, contained large blocks of limestone and of old stalagmite, as well as lumps of breccia, such as had presented themselves in the adjacent Hall.

In the more southerly parallels there was found at the base of the section, and extending quite across it from end to end, a deposit, *in situ*, of a new type, on which the Cave-earth at once rested. This proved to be a rock-like breccia composed of red earth, angular pieces of limestone, subangular and rounded pieces of grit in considerable numbers, blocks of crystalline stalagmite, and bones, all cemented into a firm and hard concrete; in short, with the single exception of its being undisturbed, it was of precisely the same character as the loose lumps previously met with in the Lecture Hall. In each succeeding parallel it rose higher and higher in the section, the overlying Cave-earth gradually thinning out.

Six feet south of its first appearance, this Breccia was found to be immediately overlaid by a Floor of Crystalline Stalagmite nearly 2 feet thick, which separated it from the Cave-earth above; in short, there were in this parallel, in the same vertical section, two Floors of Stalagmite, each immediately overlying the accumulation of detritus on which it had been formed. From this point to the end of the Eastern Division of the Chamber every parallel disclosed the two Floors; but with every additional foot southwards, the intermediate band of Cave-earth became thinner and thinner, until, before the southern wall was reached, it altogether disappeared, and the Modern Floor rested at once on the Older one. These two accumulations of stalagmite were commonly distinguishable by their different structures,—the upper being granular except when near the wall of the Cavern, the lower invariably crystalline.

In a few of the southernmost parallels, the materials at the bottom of the sections were not cemented, and there were but few bones mixed with them. In all other respects they were identical with the concrete immediately above.

It has been already stated that the Modern Floor of Stalagmite was everywhere continuous. Instead of this being the case with the Older Floor, it usually extended from each end of the section several feet towards its centre, but in all cases terminated more or less abruptly, leaving an interspace, sometimes as much as 7 feet wide.

In this branch of the Cavern, where the conditions were at once so novel and so variable, the work was watched with the utmost care, and accurate measurements and descriptions were frequently made. The following sections from different parts of the Chamber will show in a general way the succession of the deposits, in descending order:—

Section I. Near the northern end of the Eastern Division of the South-west Chamber. Length 21 feet at the top, and 11 feet at the bottom. Direction from W. 5° N. to E. 5° S. (mag.).

First, or uppermost: Modern Floor of Stalagmite, granular, continuous, contained large masses of limestone; thickness varied from 28 to 36 inches.

Second: Cave-earth, typical, contained a considerable number of large

blocks of limestone and a few pieces of crystalline stalagmite; thickness unknown, but more than 4 feet.

SECTION II. Near the middle of the Eastern Division of the South-west Chamber. Length 15 feet. Direction from W. 5° N. to E. 5° S. (mag.)

First, or uppermost: Modern Floor of Stalagmite, granular, continuous, no incorporated stones; thickness varied from 17 to 29 inches.

Second: Cave-earth, typical, contained large pieces of limestone and crystalline stalagmite; thickness varied from 3 inches at the ends of the section to 12 inches in the middle.

Third: Older Floor of Stalagmite, crystalline, discontinuous, there being a considerable hiatus near the middle of the section; thickness 14 inches.

Fourth: Rock-like Breccia, composed of red earth, small angular pieces of limestone, subangular and rounded pieces of grit, large angular masses of limestone and of crystalline stalagmite, cemented into a strong concrete; thickness unknown, but more than 31 inches. The Cave-earth rested immediately on it near the middle of the section.

SECTION III. Near the southern end of the Eastern Division of the South-west Chamber. Length 8 feet. Direction from W. 5° N. to E. 5° S. (mag.)

First, or uppermost: Modern Floor of Stalagmite, generally granular, continuous, no incorporated stones; thickness varied from 18 to 21 inches.

Second: Older Floor of Stalagmite, crystalline, discontinuous; thickness varied from 8 to 38 inches.

Third: Rock-like Breccia, in all respects like that of the 2nd section; thickness 2 feet.

Fourth: Uncemented Breccia, differing from the overlying mass only in being uncemented and in containing but few bones.

The Modern Stalagmitic Floor in this Division of the Chamber, as elsewhere in the Cavern, was found to contain a few bones and pieces of charred wood. Of the former, the most important are part of the upper jaw of the Cave-bear, containing both canines and two molars, none of which are much worn. With this fine specimen, which was extracted in the presence of the two Superintendents, several loose molars of bear were found, and also a claw of some large carnivore. Besides the foregoing, there were found elsewhere in this Floor a fine canine of *Ursus spelæus*, which does not appear to have seen much service, and an *os calcis* of some large animal.

The Cave-earth, too, no matter how thin the band to which it had dwindled, continued to the last to yield remains of its characteristic fauna. In this deposit there were found, in the Division of the Chamber now under notice, teeth and other relics of Bear, Fox, Horse, Hyæna, Rhinoceros, Mammoth, Hare, and bird. The frequency with which they were met with, rather than the aggregate number of specimens in each case, is indicated by the order in which the names stand, the remains of Bear being most prevalent, whilst those of bird were found once only. In the same branch of the Cavern was found the femur of a Bear, having the distal end perfect, but the proximal extremity wanting. This is the largest bone found during the present exploration; it was lying, with the anterior portions of the two rami of the lower jaw of a young *Hyæna spelæa*, in the fourth or lowest foot-level.

As elsewhere, many of the bones were well scored with teeth-marks, and some were split lengthways. Lumps of fæcal matter also were occasionally met with.

A few flint chips were likewise found. They are probably of artificial origin, but are not of sufficient value to require description.

Though fragments of stone which the Cavern hill could not have supplied

were much more abundant in the rock-like Breccia than in the Cave-earth, none of them were of very distant derivation: no pieces of granite from Dartmoor, or of crystalline schist from the Start and Bolt, or even of slate from the more immediate neighbourhood, all of which have been found in the Cave-earth.

The Breccia was so extremely hard and difficult to work as to render it necessary to split it out with chisels, which frequently played sad havoc with the bones it contained. These were sometimes so abundant as to form fully 50 per cent. of the entire accumulation. To use the language of one of the workmen, "they lay about as if they had been thrown there with a shovel."

The progress of the work, as in most other cases, has rendered it necessary to qualify somewhat the first impressions respecting the bones and teeth. Instead of "exclusively the remains of bear," it may be said that "almost exclusively" they are so; for recently there have been found amongst them a tooth of some cervine animal, a tooth of a Fox, and one or two bones of a bird. Moreover, some of the bones are apparently too large to have formed part of the skeleton even of *Ursus spelæus*. Nevertheless, it remains to be a fact that in this deposit there have not been identified any relics of Rhinoceros, Horse, Ox, Mammoth, Badger, Lion, or Hyæna, all of which were so frequently exhumed from the Cave-earth; nor are there any traces of fæces, or, with one solitary exception, of gnawed bones to indicate the presence of the last-named animal.

The bones found in the Cave-earth are divisible into two classes with respect to their colour. The first includes specimens of an almost chalk-like whiteness, and are very numerous; the second those of a dark tinge, and are very few. The dark hue of the second class is merely a surface discoloration. Beneath a thin superficial film, the bones of this group are just as white as those of the other. The colour of the specimens found in the Rock-like Breccia differs from that of each of the foregoing series; all of them are characterized by the same somewhat light coffee-coloured tinge, which, more or less, penetrates their entire substance.

None of these older fossils appear to have been rolled, or to have been fractured before they were lodged in the place in which they were found. Fragments of jaws are numerous, and many of them contain teeth; but, with this exception, the relics lie together without the least reference to their anatomical relations.

In many respects their condition is precisely the same as that of the specimens in the Cave-earth. Thus, those found beneath large fallen blocks of limestone are crushed, the severed parts remaining in position, and commonly held together by some firm cement. Again, other specimens are covered with a film of stalagmitic matter. Further, the bones from the older deposit adhere to the tongue just like those found in the Cave-earth, and no distinction can be drawn between the two series on this quality alone. These facts show, first, that the older formation, like the more modern one, was compact, firm, unyielding, and capable of offering resistance to a heavy falling block; second, that, as has been already remarked in the case of the Cave-earth, the bones had successively lain exposed on the surface for a long period, and that the materials of the Breccia were introduced into the Cavern at many different times, with protracted intermittences; third, that the fact that bones found in the same Cavern will adhere to the tongue with equal tenacity is not, in itself, trustworthy evidence that they are of equal antiquity.

Up to this time, the Rock-like Breccia has been utterly silent on the question of the existence of Man; it has given up no tools or chips of flint or bone, no charred wood or bones, no bones split longitudinally, no stones suggesting that they had been used as hammers or crushers. But whilst they have before them the lessons so emphatically taught by their exploration of the Cavern, the Committee cannot but think that it would be premature to draw, at present, any inference from this negative fact.

In the Western Division of the South-west Chamber, the very difficult exploration of which is now in progress, the thickness of the Stalagmitic Floor surpassed everything previously met with. Up to this time it has averaged more than 7 feet, in two instances only and over very limited spaces it was so little as 3 feet, and it has reached so much as $12\frac{1}{2}$ feet.

Cave-earth presented itself at the northern end of each section in the first seven foot-parallels only, where it was rapidly thinning out, both southwards and westwards. It was covered with its own Modern Floor of Stalagmite, and rested on the Older Floor of the same material, beneath which lay the Rock-like Breccia. This, so far as is at present known, was the termination of that great deposit of Cave-earth which, in unbroken continuity, has been followed from the entrances of the Cavern, which has yielded so many thousands of bones of extinct animals, and at least hundreds of Man's flint and bone implements and their concomitant chips, and which in other still larger branches of the Cavern awaits exploration. It will be shortly seen that to the last it was true to its character.

As in this Division the Modern Floor rested at once on the Older one and assumed a crystalline structure, especially beyond the line at which the Cave-earth disappeared, it is sometimes not easy to say how much of the great thickness just spoken of is to be ascribed to the period which separated the era of the Rock-like Breccia from that of the comparatively modern Cave-earth, and how much to the time which has elpased since the introduction of the latter deposit terminated.

In the upper part of this enormous accumulation some examples of charred wood have been found; and several stalactites, which no doubt had dropped from the roof above, have been met with lodged in the mass. There are a few peculiarities in the structure of this Stalagmite which have not been noticed elsewhere. It sometimes has a honeycombed or cellular structure, and in other places it is traversed in various directions by a series of tubular cavities, both of which have greatly contributed to the difficulty which the workmen have experienced in breaking it up; for whilst the cavities do not appear to diminish the strength of the mass, they allow the ignited gunpowder room to expand, and thus render it almost impossible to excavate it by blasting. When it is added that the Stalagmite is not traversed by great divisional planes, as almost all rocks are, and that it nearly fills the Chamber to the roof, it will be seen that at present, at least, the exploration requires very pertinacious and skilful labour.

It has been already stated that but few flint implements were found in the Lecture Hall, that these were much inferior to those brought to the Association in previous years from other parts of the Cavern, and that the Eastern Division of the South-west Chamber yielded a few chips only. It was, perhaps, not unreasonable to ascribe this paucity to the comparative remoteness of the branches of the Cavern in which the researches have been carried on during the year 1867–68. Be this as it may, the Superintendents had but little hope or expectation that better fortune was awaiting them so long as the work was day by day carrying them further on in the same

direction. Scarcely, however, had the exploration of the Western Division of the South-west Chamber commenced, when the spell was broken.

On June 25, 1868, a good implement was found 2 feet deep in the Cave earth, in a small recess in the wall of the Chamber, and sealed up with the Modern Floor of Stalagmite 80 inches thick. It was found broken, apparently into four pieces, three of which have been recovered. Some of the fractured edges are coated with Stalagmite. It lay with a fine almost unworn molar of bear, a molar of horse, and a few other teeth, one of which probably was that of a fox.

On July 4, a second implement was found. This also was 2 feet deep in the Cave-earth, over which the Stalagmite was 32 inches thick. With it there were a few bones, and immediately below it, thirteen molars of horse, a canine of hyæna, and a gnawed bone. This specimen is of the *Lanceolate type*, and is one of the finest implements the Committee have found in the Cavern. It is barely 4·2 inches long, 1·2 in greatest breadth, and ·5 inch in greatest thickness. It is strongly carinated, sharply pointed at one end, chisel-shaped at the other, and has a keen edge all round its perimeter. A great amount of labour appears to have been expended in making it, but it probably had never been used since it was last "retouched." It is of piebald flint, being partly white, and partly a dull drab. It was dug out in the presence of one of the Superintendents.

On July 10, a third implement presented itself. This was 3 feet deep in the Cave-earth, over which was 24 inches of Stalagmite. It is a fine specimen, but scarcely equal to the second, which, excepting that it is not quite so broad, and that its wider end is not chisel-shaped, it resembles in size and in form. It is made of an almost uniformly white flint.

On July 25, a fourth was met with in a recess in the wall of the Cavern, 1 foot deep in the Cave-earth, having over it upwards of 7 feet of Stalagmitic Floor. It does not appear to have been so good a specimen as either of the two last mentioned, but on this point there is some uncertainty, as it was unfortunately broken by the workmen, who, notwithstanding a careful search, were unable to recover all the fragments. Judged from the exterior only, it would have been pronounced white flint; but in consequence of the fracture it is seen that this colour is merely superficial, extending to a depth of about ·05 inch only, the interior being uniformly black. It was lying with eleven molars of horse, a sectorial tooth of hyæna, several bones and bone fragments, and a few small lumps of fæcal matter. Judging from the character of its point, this implement was a "borer."

Thus, within about a month, four flint implements, all of them good, and two of them very fine specimens, were found within a space of 5 feet, and from 140 to 150 feet from the nearest of the external entrances of the Cavern. They were attended by the usual accompaniments, and with the last of them the Cave-earth terminated in that direction, so far as is at present known.

The Rock-like Breccia in this Division of the Chamber presented the ordinary characteristics, and calls for no special remark.

In their Third Report (1867) the Committee called attention to the facts which, successively and slowly discovered, had led to the conviction that there was a Chapter in the history of the Cavern earlier than that represented by the Cave-earth. It has been already stated, and at some length, that further and most conclusive evidence on the point has presented itself during the year 1867–68. The case is of so much interest, so characteristic of Cavern researches, and so full of instruction and encouragement, that it

may be worth while to give a brief recapitulation of the facts from the beginning:—

1st. The Committee had been at work upwards of five months when cuboidal blocks of Stalagmite first appeared in the Cave-earth and in the overlying Stalagmitic Floor. After much deliberation, it was concluded that they were fragments of an older Floor, which had covered a deposit of still higher antiquity, and had been wholly or partially broken up before or during the introduction of the Cave-earth in which the blocks were lodged. To this conclusion, there was the great objection that there were no bones or stones either within or attached to the blocks.

2nd. After the labour of six further months, during which every day disinterred additional blocks, but with the same negative characters, a large portion of an old Floor was actually found *in situ*, but without having beneath it any trace of a deposit which it had once sealed up. Though the probable interpretation was that the deposit had been washed out, or had sunk away from the floor through failure of support at its base, it seemed reasonable to suppose that, in either case, stones or other remnants of it would be found attached to the lower surface of the Floor. Instead of presenting such relics, however, this lower surface was a beautiful cream-coloured plate of stalagmite, bristling with short stalactites of the same colour.

3rd. In order to determine whether the so-called "remnant of old Floor" was really stalagmitic throughout, several holes were bored through it, which not only decided the question affirmatively, but caused a portion of its nether surface to scale off, and to disclose the fact that the "cream-coloured plate" was but a modern veneer formed on what had been the original surface; and this, when thus laid bare, proved to be soil-stained and crowded with small particles of detrital matter—relics of the missing mechanical deposit.

4th. After this, seventeen months passed, and though in the meantime blocks of stalagmite were found everywhere, and some of them of great size, and though the workmen purposely broke them into small pieces, still no bone or stone was found within or projecting from them. At length, at the end of the time just mentioned, one of them was broken and a bone was found within it. After this, ossiferous blocks of stalagmite were dug out frequently, and some of them were found to contain stones also.

5th. Within the compass of another month, loose round lumps of Rock-like Breccia were met with in the Cave-earth, and, from their composition and external form, were regarded as dislodged remnants of the older deposit which had so long been seen by the mind's eye only. This opinion was strengthened by the fact that the bones with which they were crowded did not appear to represent precisely the same fauna as did those met with in the Cave-earth.

6th. At the end of six additional months, the workmen came upon the old deposit *in situ*, having all the characters of the lumps just mentioned, but not separated from the Cave-earth above it by any Floor of Stalagmite.

7th. At the close of a further period of six weeks, or after three full years of daily research, there was found, in one and the same vertical section, the Old deposit of Breccia capped by its Stalagmite, on which lay the Cave-earth, protected, in its turn, by *its* Stalagmitic Floor also. The early inference from the blocks alone was justified; not a link of the evidence was missing. The entire chain was presented to the eye at one view. The case was at length complete.

The following fact may be appropriately mentioned in connexion with this case. As has been already stated, a Subcommittee of the Torquay Natural-History Society, in 1846, broke through the Modern Stalagmitic Floor in the

South-west Chamber, and excavated the Cave-earth to the depth of 2 feet, when, having found nothing, they abandoned the work. Had they continued their labours but another half hour, had they dug but 2 inches lower, they would have entered the richly ossiferous Breccia, and, in all probability, caught sight of the earlier chapter of the history of the Cavern.

It has been already mentioned that the Rock-like Breccia contains, amongst other things, considerable pieces of stalagmite. There can be no doubt that the same interpretation applies to these as applied to those found in the Cave-earth. If the latter were correctly regarded as evidence of a floor older than the deposit in which they were lodged, the former must be held to indicate the existence of a floor still older than the Breccia—a floor of the third order of antiquity, which, in harmony with the terminology hitherto used, may, for the present at least, be termed the "Oldest Floor of Stalagmite."

If the present state of the evidence be trustworthy, the Cavern, during the era of the Rock-like Breccia, was almost exclusively a mausoleum for *Ursus spelæus*. Up to this time, no trace of *Hyæna spelæa*, *Felis spelæa*, *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus fossilis*, or of several other well-known cavern species has been found in the old deposit. Though he was subsequently their contemporary in Devonshire, the Great Cave-Bear, so far as the present evidence goes, seems to have had his home there very long before them.

The Committee have again to state that they have not yet had the good fortune to discover any remains of *Hippopotamus major* or *Machairodus latidens*, either in the Cave-earth or in the Breccia.

Whilst it must be admitted that the labours of the past twelve months have not added anything to the kind, or very greatly to the amount, of evidence of the antiquity of Man in Devonshire, it must also be admitted that the continued and careful researches of three and a half years have utterly failed to detect a single fact having even a remote tendency to invalidate the conclusion to which the early Cavern researches had led. Up to this time, the various kinds of evidence are in the most complete accord; there is nothing conflicting. No comparatively modern object has been found below its place, and no ancient one has been met with in a modern niche. The Modern Floor of Stalagmite has kept the two apart and perfectly distinct. There is nothing incongruous in the belief that the ancient Cave-Men made and used unpolished flint implements, split the bones of animals, and cut and scraped the fragments into pins and fish-spears, employed fire in the preparation of their food, and selected some stones for hammers or crushers, and others to rub down the asperities on their bone tools; and this belief apparently embraces all the Cavern Anthropology which up to this time has been discovered.

The researches of 1867–68, however, have been by no means barren or unimportant. They have, as has been pointed out, established the existence of two Chapters in the Cavern history during the times of the extinct mammals, and have given a glimpse of a third and still earlier one; they have solved one problem, and, in doing so, have suggested several others; they have given an increased stimulus to research by prompting the following questions:—

1st. What were the conditions which at three different and widely separated times allowed detrital matter to be carried into the Cavern?

2nd. How was the introduction of this material suspended during, at least, two protracted periods, in which thick floors of Stalagmite were formed?

3rd. By what agency were these floors partially and largely broken up? and why, where they have been removed, have they left no scar on the walls of the Cavern?

4th. Since, heretofore, Suspension has been followed by Excavation and Re-introduction, may this recur at some future time?

5th. Had the Great Cave-Bear any spelæan contemporaries at first? and, if so, What were they? and was *Machairodus latidens* or *Hippopotamus major* amongst them?

6th. How, during the era of the Breccia, were the remains of the Cave-Bear carried into the Cavern, seeing that none of them are rolled, broken, or gnawed, yet they lie together without the least reference to their anatomical relations?

It may be hoped that future researches may furnish solutions for at least some of these questions.

On Puddling Iron. By C. W. SIEMENS, *F.R.S.**

NOTWITHSTANDING the recent introduction of cast steel for structural purposes, the production of wrought iron (and puddled steel) by the puddling process ranks among the most important branches of British manufacture, representing an annual production exceeding one and a half million of tons, and a money value of about nine millions sterling.

Although the puddling process must be admitted to be of great commercial importance, and involves most interesting chemical problems, it has received less scientific attention than other processes of more recent origin and inferior importance, owing probably to the mistaken sentiment that a time-honoured practice implies perfect adaptation of the best means to the end, and leaves little scope for improvement.

The scanty scientific literature on the subject will be found in Dr. Percy's important work on iron and steel. Messrs. Crace-Calvert and Richard Johnson of Manchester† have supplied most valuable information by a series of analyses of the contents of a puddling-furnace during the different stages of the process. These prove that the molten pig metal is mixed intimately, in the first place, either with a molten portion of the oxides, (or fettling,) which form the lining or protecting covering to the cast-iron tray of the puddling-chamber, or with a proportion of oxide of iron in the form of

* Ordered to be printed *in extenso* among the Reports.

† Phil. Mag., September 1857. The following Table from Messrs. Calvert and Johnson's paper includes the chief results of their investigations:—

	Time.	Carbon.	Silicon.
Pig iron charged	12·	2·275	2·720
Sample No. 1	12·40	2·726	0·915
,, ,, 2	1·0	2·905	0·197
,, ,, 3	1·5	2·444	0·194
,, ,, 4	1·20	2·305	0·182
,, ,, 5	1·35	1·647	0·183
,, ,, 6	1·40	1·206	0·163
,, ,, 7	1·45	0·963	0·163
,, ,, 8	1·50	0·772	0·168
Puddled bar ,, 9	......	0·296	0·120
Wire iron ,, 10	......	0·111	0·088

hammer-slag or red ore, thrown in expressly with the charge, that the silicon is first separated from the iron, that the carbon only leaves the iron during the "boil" or period of ebullition, and that the sulphur and phosphorus separate last of all while the metal is "coming to nature."

The investigations by Price and Nicholson and by M. Lan confirm these results, from which Dr. Percy draws some important general conclusions, which have only to be followed up and supplemented by some additional chemical facts and observations in order to render the puddling process perfectly intelligible, and to bring into relief the defective manner in which it is at present put into practice, involving, as it does, great loss of metal, waste of fuel and of human labour, and an imperfect separation of the two hurtful ingredients, sulphur and phosphorus.

Silicon.—In forming (by means of the rabble) an intimate mechanical mixture between the fluid cast metal and the cinder, the silicon contained in the iron is brought into intimate contact with metallic oxide, and is rapidly attacked, being found afterwards in the cinder in the form of silicic acid (combined with oxide of iron). The heat of the furnace is always kept low during this stage of the process, and the flame is maintained as reducing as possible.

Carbon.—The disappearance of the carbon from the metal is accompanied by the appearance of violent ebullition and the evolution of carbonic oxide, which rises in innumerable bubbles to the surface of the bath, and burns (in an ordinary puddling-furnace) with the blue flame peculiar to that gas. In puddling in a regenerative gas-furnace this blue flame cannot be observed, because the flame of this furnace is strictly neutral, and there is no free oxygen present to burn the carbonic oxide rising from the fluid mass—a circumstance which by itself explains the superior results obtained from the gas furnace.

It is popularly believed that the oxygen acting upon the silicon and carbon of the metal is derived directly from the flame, which should, on that account, be made to contain an excess of oxygen; but the very appearance of the process proves that the combination between carbon and oxygen does not take place on the surface, but throughout the body of the fluid mass, and must be attributed to the reaction of the carbon upon the fluid cinder in separating from it metallic iron; while as the removal of the silicon is still more rapid, and is effected under a reducing flame, there is strong evidence that it also is oxidized rather by the oxygen of the cinder than by the flame*.

But it has been argued that, although the reaction takes place below the surface, the oxygen may, nevertheless, be derived from the flame, which may oxidize the iron on the surface, forming an oxide or cinder, which is then transferred to the carbon at the bottom, in consequence of the general agitation of the mass.

This view I am, however, in a position to disprove by my recent experience in melting cast steel upon the open flame-bed of a furnace, having invariably observed that no oxidation of the unprotected *fluid metal* takes place so long as it contains carbon in however slight a proportion.

But being desirous to ascertain by positive proof what is the behaviour of silicon and carbon in fluid cast iron when contact with the atmosphere or the flame of the furnace is strictly prevented, I instituted the following experiment at my Sample Steel Works at Birmingham:—

* At the end of this paper is appended a Table showing the comparative quantities of carbon in various kinds of iron and steel.

Ten cwt. of Acadian pig metal and 1 cwt. of broken glass were charged upon the bed of a regenerative gas furnace (usually employed for melting steel upon the open hearth).

The bed of this furnace was formed of pure siliceous sand, and one object in view was to ascertain whether any reaction takes place between silica and fluid cast metal, it being generally supposed that metallic silicon is produced under such circumstances by the reducing action of the carbon in the metal upon the silica or silicates present.

The cast metal employed in this experiment was Acadian pig containing

Silicon .... 1·5 per cent.
Carbon .... 4·0 „

In the course of an hour the metal and glass were completely melted. A sample was taken out, containing

Silicon .... 1·08 per cent.
Carbon .... 2·90 „ $\left\{\begin{array}{l}\cdot6 \text{ per cent. combined carbon.}\\ 2\cdot3 \text{ „ graphite.}\end{array}\right.$

At the end of the second hour another sample was taken out and tested, the result being,

Silicon .... ·96 per cent.
Carbon .... 2·40 „ combined.

The physical condition of the metal had now undergone a decided change; the carbon having wholly combined with the iron, rendered it extremely hard.

The amount of silicon having steadily diminished, these results prove that *no silicon is taken up by fluid cast metal in contact with silica or silicates.*

The reduction of the amount of silicon in the metal might be accounted for by the presence of minute quantities of oxides of iron, produced in melting the pig metal, which oxides were now increased by the addition of hæmatite ore in small quantities.

At the end of the third hour another sample was taken, containing

Silicon .... ·76 per cent.
Carbon .... 2·40 „ combined,

the metal being extremely hard as before. Additional doses of red ore were added gradually without agitating the bath, and the effect upon the fluid metal was observed from time to time.

At the end of the fifth hour the samples taken from the fluid bath assumed a decidedly mild temper, when the addition of ore was stopped, and exactly six hours after being charged the metal was tapped and run into ingots; it now contained

Silicon .... ·046 per cent.
Carbon .... ·250 „

Thus both the silicon and the carbon had been almost entirely removed from the pig metal by mere contact with metallic oxide, under a protecting glass covering.

The quantity of red ore added to the bath amounted to 2 cwt., and the weight of metal tapped to 10 cwt. 5 lbs., being slightly in excess of the weight of pig metal charged.

But the pig metal had contained

Silicon .... 1·5 per cent.
Carbon .... 4·0 „
Total .... 5·5 „

whereas the final metal contained only ·296 of silicon and carbon, showing a gain of metal of

$$5{\cdot}5 - {\cdot}296 = 5{\cdot}204 \text{ per cent.},$$

or, including the 5 lbs. of increased weight, a total gain of 5·7 per cent. of metallic iron.

Supported by these observations, I venture to assert that *the removal of the Silicon and Carbon from the pig iron in the ordinary puddling or "boiling" process is due entirely to the action of the fluid oxide of iron present, and that an equivalent amount of metallic iron is reduced and added to the bath*, which gain, however, is generally and unnecessarily lost again in the subsequent stages of the process. The relative quantity of metal thus produced from the fluid cinder admits of being accurately determined.

The cinder may be taken to consist of $Fe^3\,O^4$ (this being the fusible combination of peroxide and protoxide), together with more or less tribasic silicate ($3\,FeO, SiO^3$), which may be regarded as a neutral admixture, not affecting the argument, and silicic acid or silica is represented by $Si\,O^3$, from which it follows that for every four atoms of silicon leaving the metal, nine atoms of metallic iron are set free; and taking the atomic weights of iron $=28$, and of silicon $=22{\cdot}5$, it follows that for every

$$4 \times 22{\cdot}5 = 90{\cdot}0$$

grains of silicon abstracted from the metal,

$$9 \times 28 = 252$$

grains of metallic iron are liberated from the cinder.

Carbonic oxide, again, being represented by CO, and the cinder by $Fe^3\,O^4$, it follows that for every four atoms of carbon removed from the metal three atoms of iron are liberated; and taking into account the atomic weights of carbon $=6$ and of iron $=28$, it follows that for every

$$6 \times 4 = 24$$

grains of carbon oxidized,

$$28 \times 3 = 84$$

grains of metallic iron are added to the bath. Assuming ordinary forge pig, after being remelted in the puddling-furnace, to contain about 3 per cent. of carbon and 2 per cent. of silicon, it follows from the foregoing that in removing this silicon

$$\frac{252}{90} \times 2 = 5{\cdot}6 \text{ per cent., and in removing the carbon}$$

$$\frac{84}{24} \times 3 = 10{\cdot}5$$

per cent. of metallic iron is added to the bath, making a total increase of

$$5{\cdot}6 + 10{\cdot}5 - 5 = 11{\cdot}1$$

per cent., or a charge of 420 lbs. of forge pig metal ought to yield 466 lbs. of wrought metal, whereas from an ordinary puddling-furnace the actual yield would generally amount to only 370 lbs. (or 12 per cent. less than the charge), showing a difference of 96 lbs. between the theoretical and actual yield in each charge.

This difference, amounting to fully 20 per cent., is due to the enormous waste by oxidation to which the iron is exposed after it has been "brought to nature" (by the removal of the carbon), when it is in the form of a granular or spongy metallic mass and during the process of forming it into balls. So great a waste of metal by oxidation seems at first sight almost incredible; but considering the extent of surface exposed in the finely divided puddled mass, it is not at all exceptional, and is in fact almost unavoidable in a furnace of the ordinary construction, maintained as a puddling-furnace is at a welding heat. Many attempts have been made (for example, by

Chenot, Clay, Renton, and others) to produce iron directly from the purer ores, by reducing the ore in the first instance to a metallic sponge, and balling up this sponge, which is a loose porous mass somewhat similar to spongy puddled iron, on the bed of a furnace; but all these attempts have failed, simply on account of the great waste of iron, a waste amounting to from 25 to 50 per cent. in balling up the sponge. Indeed the loss in an ordinary puddling-furnace would probably be greater than 20 per cent. if the metal were not partly protected from the flame by the bath of cinder in which it lies; for in one instance in which the cinder accidentally ran out of a puddling-furnace during the balling up of the charge, leaving the iron exposed to the flame, I found the yield reduced from the average of 413 lbs. down to 370 lbs., showing an increased waste of 43 lbs., or over 10 per cent., due to the more complete exposure of the metal to the oxidizing action of the flame.

In order to realize the theoretical result, a sufficient amount of oxides must have been supplied to effect the oxidation of the silicon and carbon of the pig iron, and to form a tribasic silicate of iron ($3FeO, SiO^3$) with the silicic acid produced.

The amount of oxide required may be readily ascertained.

In taking the expression $Fe^3 O^4$, the atomic weight of which is

$$3 \times 28 + 4 \times 8 = 116,$$

while that of the three atoms of iron alone is

$$3 \times 28 = 84,$$

it follows that

$$\frac{116}{84} \times 46 = 63{\cdot}5 \text{ lbs.}$$

of cinder or oxide of iron are requisite to produce the 46 lbs. of reduced iron which were added to the bath. There must, however, remain a sufficient quantity of fluid cinder in the bath to form with the silicon (extracted from the iron) a tribasic silicate of iron, or about 60 lbs., making in all 124 lbs. of fettling, which would have to be added for each charge, a quantity which is generally exceeded in practice, notwithstanding the inferior results universally obtained.

There remain for our consideration the sulphur and phosphorus, which being generally contained in English forge pig in the proportion of from ·2 to ·6 per cent. each, can hardly affect the foregoing quantitative results, although they are of great importance as affecting the quality of the metal produced.

It has been suggested by Percy that the separation of these ingredients may be due to *liquation*. This I understand to mean that the crystals of metallic iron which form throughout the boiling mass when the metal "comes to nature," exclude foreign substances in the same way that the ice formed upon sea-water excludes the salt, and yields sweet water when remelted.

According to this view, pig metal of inferior quality will really yield iron almost chemically pure, to which foreign ingredients are again added by mechanical admixture with the surrounding cinder, or semireduced metal.

It may be safely inferred that the freedom of the metal from impurities thus taken up will mainly depend upon the temperature, which should be high, in order to ensure the perfect fluidity and complete separation of the cinder.

Led by these chemical considerations, and by practical attention to the subject, extending over several years, I am brought to the conclusion *that the process of puddling, as practised at present, is extremely wasteful in iron and fuel, immensely laborious, and yielding a metal only imperfectly separated from its impurities.*

How nearly we shall be able to approach the results indicated by the che-

mical reasoning here adopted, I am not prepared to say; but that much can be accomplished by the means actually at our doors is proved by the result of the working of a puddling-furnace erected eighteen months since to my designs by the Bolton Steel and Iron Company in Lancashire.

This furnace consists of a puddling-chamber of very nearly the ordinary form, which is heated, however, by means of a regenerative gas furnace, a system of which the principle is now sufficiently well established to render a very detailed description here unnecessary. The general arrangement of the furnace is shown in the accompanying illustrations. It consists of two essential parts:—

The Gas-producer, in which the coal or other fuel is converted into a combustible gas; and

The Furnace, with its "regenerators" or chambers for storing the waste heat of the flame, and giving it up to the incoming air or gas.

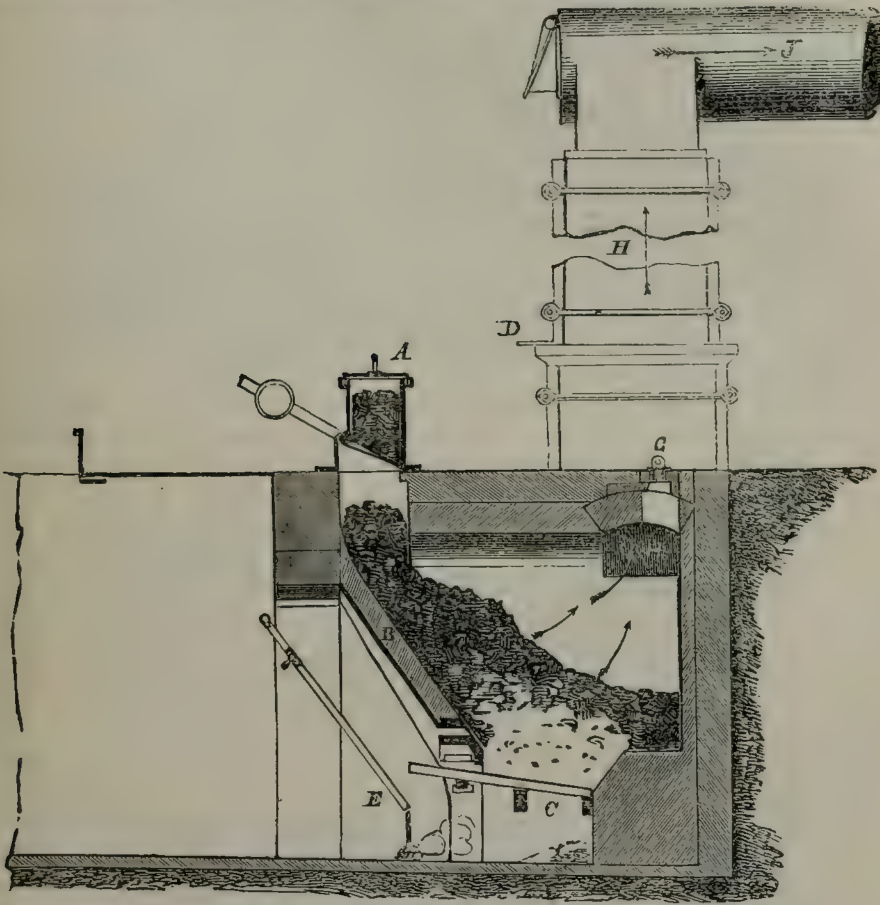


Fig. 1.—Section of Gas-producer. Scale $\frac{3}{16}$ inch to a foot.

The Gas-producer is shown in fig. 1; it is a rectangular firebrick chamber, one side of which, B, is inclined at an angle of from 45° to 60°, and is provided with a grate, C, at its foot. The fuel, which may be of any description, such as coal, coke, lignite, peat, or even sawdust, is filled in through a hopper, A, at the top of the incline, and falls in a thick bed upon the grate.

Air is admitted at the grate, and, in burning, its oxygen unites with the carbon of the fuel, forming carbonic-acid gas, which rises slowly through

the ignited mass, taking up an additional equivalent of carbon, and thus forming carbonic oxide. The heat thus produced distils off carburetted hydrogen and other gases and vapours from the fuel as it descends gradually towards the grate, and the carbonic oxide already named, diluted by the inert nitrogen of the air, and by any small quantity of unreduced carbonic acid, and mixed with these gases and vapours distilled from the raw fuel, is finally led off by the gas-flue to the furnace. The ashes and clinkers that accumulate in the grate are removed at intervals of one or two days.

E is a pipe for the purpose of supplying a little water to the ash-pit, to be decomposed as it evaporates and comes in contact with the incandescent fuel, thus forming some hydrogen and carbonic oxide, which serve to enrich the gas; G is a small plughole by which the state of the fire may be inspected, and the fuel moved by a bar if necessary; and D is a sliding damper by which the gas-producer may be shut off at any time from the flue.

It is necessary to maintain a slight outward pressure through the whole length of the gas-flue leading to the furnaces, in order to prevent the burning of the gas in the flue through the indraught of air at crevices in the brickwork.

Where the furnaces stand much higher than the gas-producers, the required pressure is at once obtained; but more frequently the furnaces and gas-producers are placed nearly on the same level, and some special arrangement is necessary to maintain the pressure in the flue. The most simple contrivance for this purpose is the "elevated cooling-tube." The hot gas is carried up by a brick stack, H, to a height of eight or ten feet above the top of the gas-producer, and is led through a horizontal sheet-iron cooling-tube, J (fig. 1), from which it passes down either directly to the furnace, or into an underground brick flue.

The gas rising from the producer at a temperature of about 1000° Fahr., is cooled as it passes along the overhead tube, and the descending column is consequently denser and heavier than the ascending column of the same length, and continually overbalances it. The system forms, in fact, a siphon in which the two limbs are of equal length, but the one is filled with a heavier gaseous fluid than the other.

In erecting a number of gas-producers and furnaces, I generally prefer to group the producers together, leading the gas from all into one main flue, from which the several furnaces draw their supplies.

The Puddling-Furnace proper is shown in figures 2, 3, and 4.

Fig. 2 is a front elevation of the furnace, showing the gas-reversing valve and flues in section.

Fig. 3 is a longitudinal section at A, B, C, D (fig. 4).

Fig. 4 is a sectional plan at L, M (fig. 3).

The peculiarity of the regenerative gas furnace, as applied either to puddling or to any other process in which a high heat is required, consists in the utilization *in the furnace* of nearly the whole of the heat of combustion of the fuel, by heating the entering gas and air by means of the waste heat of the products of combustion after they have left the furnace, and are of no further use for the operation being carried on. The waste heat is, so to speak, intercepted on its passage to the chimney by means of masses of firebrick stacked in an open or loose manner in certain chambers, called "regenerator chambers," C, E, $E_{,}$, $C_{,}$ (fig. 3).

On first lighting the furnace the gas passes in through the gas-regulating valve, B (fig. 2), and the gas-reversing valve, B′, and is led into the flue, M, and thence into the bottom of the regenerator chamber, C (fig. 3); while the

air enters through a corresponding "air-reversing valve," behind the valve,

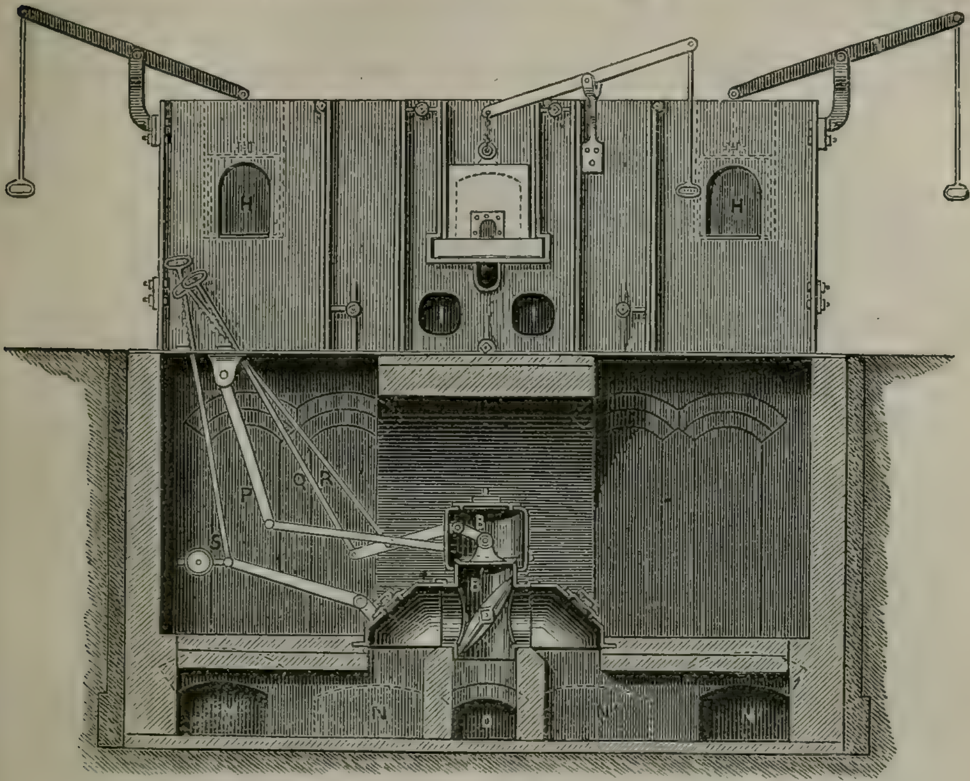


Fig. 2.—Front Elevation of Puddling-Furnace. Scale $\frac{3}{16}$ inch to a foot.

B′ (fig. 2), and passes thence through the flue, N, into the regenerator chamber, E (fig. 3).

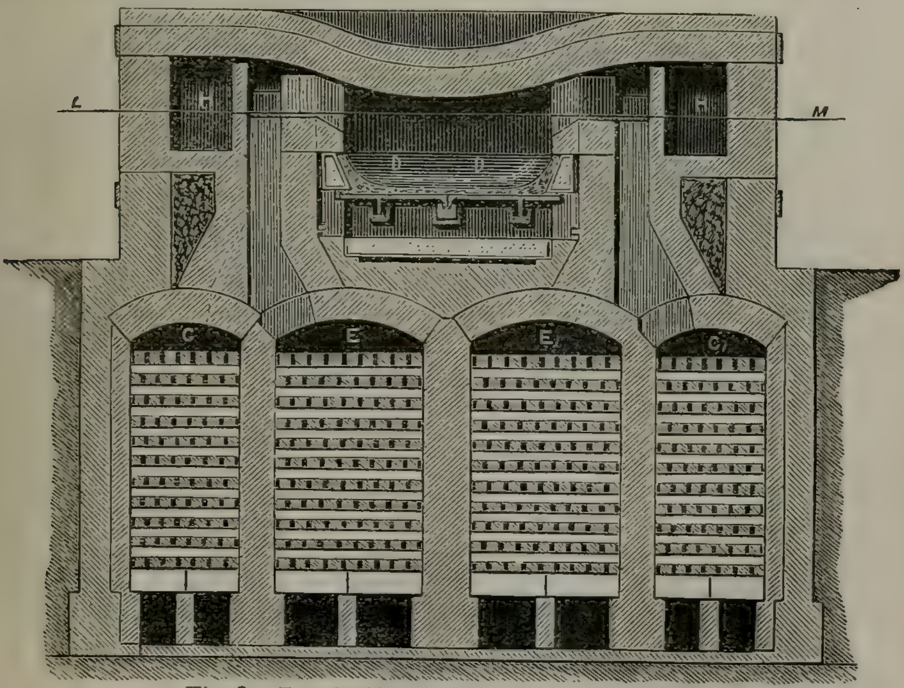


Fig. 3.—Longitudinal Section at A, B, C, D (fig. 4).

The currents of gas and air, both quite cold, rise separately through the regenerator chambers, C and E (fig. 3), and pass up through the flues, G, G, and F, F, F (fig. 4) respectively, into the furnace above, where they meet and are lighted, burning and producing a moderate heat. The products of combus-

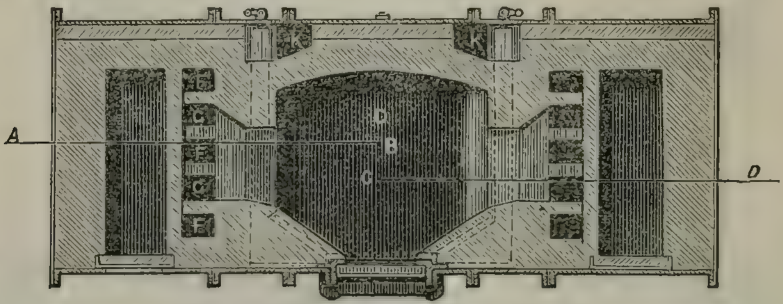


Fig. 4.—Sectional Plan at L, M (fig. 3).

tion pass away through a similar set of flues at the other end of the furnace into the regenerator chambers C$_{,}$, E$_{,}$ (fig. 3), and thence through the flues M′, N′ (fig. 2), and through the gas- and air-reversing valves into the chimney-flue, O. The waste heat is thus deposited in the upper courses of open fire-brick work filling the chambers, C$_{,}$, E$_{,}$ (fig. 3), so heating them up, while the lower portion and the chimney-flue are still quite cool; then, after about an hour, the reversing-valves, B′ (fig. 2) (through which the air and gas are admitted to the furnace) are reversed, by means of the levers, P, and the air and gas enter through those regenerator chambers, E$_{,}$, C$_{,}$ (fig. 3), that have just been heated by the waste products of combustion, and in passing up through the open brickwork they become heated, and *then*, on meeting and entering into combustion in the furnace, D, D, they produce a very high temperature, probably 500° Fahr. higher than when admitted cold; the waste heat from such *higher temperature of combustion* heating up the previously cold regenerator chambers, C, E, to a correspondingly higher heat.

After about an hour's work, the reversing-valves, B′ (fig. 2), are again reversed, and the air and gas enter the first pair of regenerator chambers, C, E (fig. 3), but which are now very hot, and therefore the air and gas become very hot, and enter the furnace in this state, meeting and entering into combustion, and thus producing a still higher temperature, probably 500° higher still, and again heating the second pair of regenerator chambers, C$_{,}$, E$_{,}$, so much higher, which enables them to again heat the air and gas to a still higher degree, when the valves, B′ (fig. 2), are again reversed. Thus an *accumulation* of heat and an accession of temperature is obtained, step by step, so to speak, until the furnace is as hot as is required; for unless cold materials are put in to be heated, and thus abstract heat, the temperature rises as long as the furnace holds together, and the supply of gas and air is continued. The heat is at the same time so thoroughly abstracted from the products of combustion by the regenerators, that the chimney-flue remains always quite cool. The command of the temperature of the furnace and of the quality of the flame is rendered complete by means of the gas and air regulating valves shown at B, in fig. 2, and by the chimney-damper. These are adjusted to any required extent of opening by the notched rods, Q, R, and S (fig. 2), respectively, so that, having the power of producing as high a temperature as can be desired, there is also the power of varying it according to the requirements in each case.

The bed of the furnace, D D (fig. 3), is of the ordinary construction, formed of iron plates, and is provided with water-bridges at the ends, as shown, to

protect the "fettling" (or oxide of iron used for lining the furnace) from being melted away. The overflow from one of the water-bridges is led into a sheet-iron tank below the bed, and then away. The evaporation from this tank keeps the bottom plates cool and preserves the cinder covering them from melting off, and the steam is carried away by a draught of air entering through two holes, I, I (fig. 2), below the tap-hole, and passing off by small ventilating shafts, K, K (fig. 4), at the back of the furnace.

A heating chamber, H (fig. 3), is arranged at each end of the furnace, in which the charge of pig iron may be heated to redness before it is introduced into the puddling-chamber, D D.

The advantages of this furnace for puddling are, that the heat can be raised to an almost unlimited degree, that the flame can be made at will oxidizing, neutral, or reducing, without interfering with the temperature, that indraughts of air and cutting flames are avoided, and that the gas-fuel is free from ashes, dust, and other impurities which are carried into an ordinary puddling-furnace from the grate. In this last respect, the new furnace presents the same advantages as puddling with wood.

The following Tables give the working results which were obtained from this furnace, as compared with the results obtained at the same time in an ordinary furnace from the same pig (the ordinary forge mixture).

Regenerative Gas Furnace.

TABLE No. 1.

Date.	No. of heat.	Time charged.	First ball out.	Metal charged.	Yield.
			First shift.		
		h. m.	h. m.	lbs.	lbs.
1867.	1	5 25	6 32	410	392
May 7.	2	6 45	7 50	433	396
	3	8 8	9 9	430	410
	4	9 15	10 7	425	426
	5	10 20	11 22	426	430
	6	11 40	12 46	412	412
			Second shift.		
	1	1 48	2 47	428	410
	2	2 50	3 47	420	414
	3	3 56	4 53	426	418
	4	5 0	6 3	432	417
	5	6 5	7 12	425	407
	6	7 20	8 15	420	422
			Third shift.		
	1	9 10	10 15	423	414
	2	10 25	11 30	422	412
	3	11 35	12 40	420	420
	4	12 45	2 0	430	410
	5	2 10	3 10	424	418
	6	3 16	4 20	420	400

TABLE No. 1 (*continued*).

Date.	No. of heat.	Time charged.	First ball out.	Metal charged.	Yield.
		First shift.			
1867.		h. m.	h. m.	lbs.	lbs.
May 28.	1	5 38	6 45	423	402
	2	6 50	8 0	422	400
	3	8 6	9 8	430	390
	4	9 15	10 25	426	407
	5	10 35	11 45	426	420
	6	11 55	1 8	430	416
		Second shift.			
	1	2 0	3 1	422	422
	2	3 6	4 0	424	415
	3	4 5	5 18	423	424
	4	5 23	6 27	423	415
	5	6 33	7 46	427	420
	6	7 49	8 50	420	406
		Third shift.			
	1	10 0	11 20	420	424
	2	11 25	11 33	420	410
	3	12 40	1 45	423	412
	4	1 50	2 58	425	420
	5	3 13	4 20	430	418
	6	4 30	5 35	422	426

	cwt.	qrs.	lbs.		cwt.	qrs.	lbs.
Total yield	132	2	2	Total charge ..	136	1	2

being at the rate of 20 cwt. 2 qrs. 2 lbs. of pig iron per ton of puddled bar.

Ordinary Furnace.

TABLE No. 2.

Date.	Time.	Weight of metal charged.	Weight of puddled bar produced.	Date.	Time.	Weight of metal charged.	Weight of puddled bar produced.
			lbs.				lbs.
1867. May 17	These times were not taken for each charge, but 6 heats were produced every 12 hours.	Mean 484 lbs.	424	1867. May 17	These times were not taken for each charge, but 6 heats were produced every 12 hours.	Mean 484 lbs.	432
			425				426
			405				420
			430				422
			430				422
			438				425
			416				430
			456				450
			410				410

Mean charge	484 lbs.
Mean yield	426 ,,

or 22 cwt. 2 qrs. 20 lbs. of pig iron per ton of puddled bar.

It will be observed that the ordinary furnace received charges of 484 lbs. each, and yielded on an average 426 lbs., representing a loss of 12 per cent., whereas the gas furnace received charges averaging 424 lbs., and yielded 413 lbs., representing a loss of less than 2·6 per cent.

It is important to observe, moreover, *that the gas furnace turned out eighteen heats in three shifts per twenty-four hours*, instead of only twelve heats per twenty-four hours, which was the limit of production in the ordinary furnace.

This rate of working was attained without the employment of any arrangement for heating the pig iron before charging it into the furnace, the heating-chambers at the ends not having been used. The adoption of the plan of heating the metal beforehand (a system already extensively in use both in this country and on the Continent) effects a further saving of ten to fifteen minutes in the time required for working each charge, as well as a considerable economy in fuel.

The quality of the iron produced from the gas furnace was proved decidedly superior to that from the ordinary furnace, being what is technically called "*best best*" in the one, and "*best*" in the other case, from the same pig iron of average quality.

The following was the result of an analysis of an inferior English pig iron before and after being puddled in the gas furnace:—

Pig Metal.		Puddled Bar.	
Sulphur	·08	Sulphur	·017
Phosphorus	1·16	Phosphorus	·237
Silicon	1·97	Silicon	·200
Iron and Carbon (by difference)	96·79	Iron by difference	99·546
	100·00		100·000

showing the extent to which foreign matters are actually removed by the process of puddling.

These analyses were made a few days ago by Mr. A. Willis in my laboratory at Birmingham.

The economy of fuel was also greatly in favour of the gas furnace, but could not be accurately ascertained, because some mill-furnaces were worked from the same set of producers. Still, judging from the experience of several years in the working of regenerative gas furnaces as reheating or mill-furnaces and as glass-furnaces, the saving of fuel in puddling cannot be less than 40 to 50 per cent. in quantity, while a much cheaper quality may be used.

The consumption of "fettling" was, however, greater in the gas furnace, and the superior yield was naturally attributed by the forge managers to that cause, although the writer held a different opinion.

The gas furnace, however, had not been provided with water-bridges; these were subsequently added, and the furnace put to work again in February last, since which time it has been worked continuously.

The result of the water-bridges has been that the amount of "fettling" required is reduced to an ordinary proportion, the average quantity of red ore used being 92·6 lbs. per charge, besides the usual allowance of bulldog,

while the yield per charge of 483·3 lbs. of grey forge pig has been increased to 485 lbs. of puddled bar, as shown by the following return of a series of eighty consecutive charges in June last:—

Regenerative Gas Furnace.

TABLE No. 3.

Date.	No. of heats.	Total charges and yields.					Average per heat.
			lbs.	cwt.	qr.	lbs.	lbs.
June 1868.	80	Pig iron charged	38,668=	345	1	0	483·3
		Puddled bar returned	38,808=	346	1	25	485
		Red ore for "fettling"	7,406=	66	0	14	92·6

proving that *the yield of puddled bar slightly exceeds the charge of pig metal* (representing a saving of fully 12 per cent. over the ordinary furnace), *while the superiority of quality in favour of the gas furnace is fully maintained.*

It is also worthy of remark that these results are obtained regularly by the ordinary puddlers of the works, and that no repairs have been necessary to the gas puddling-furnace since November last, the roof being reported to be still in excellent condition.

In these investigations I have confined myself to the puddling of ordinary English forge pig, in order to avoid confusion; but it is self-evident that the same reasoning also applies, in a modified degree, to white pig metal or refined metal, the use of which I should not, however, advocate.

Water-bridges.—Regarding the water-bridges, I was desirous to ascertain the expenditure of heat at which the saving of "fettling" and greater ease of working was effected. The water passing through the bridges was accordingly measured by Mr. W. Hackney (who has also furnished me with the other working data), and found to amount to 25 lbs. per minute, heated 40° Fahr. This represents 60,000 units of heat per hour, or a consumption not exceeding 8 lbs. to 10 lbs. of solid fuel per hour, an expenditure very much exceeded by the advantages obtained where water or cooling-cisterns are available.

The labour of the puddler and of his underhand being very much shortened and facilitated by means of the furnace, I should strongly recommend the introduction of three working shifts of 8 hours each per 24 hours, each shift representing the usual number of heats, by which arrangement both the employer and the employed would be materially benefited.

The labour of the puddler may be further reduced with advantage by the introduction of the mechanical "rabble," which has already made considerable progress on the Continent.

By working in this manner, a regenerative gas puddling-furnace, of ordinary dimensions, would produce an annual yield of about 940 tons of bar iron, of superior quality, from the same weight of grey pig metal and the ordinary proportion of "fettling."

In conclusion I may state that a considerable number of these puddling-furnaces have been erected by me abroad, and that in this country they are also being taken up by the Monkbridge Iron Company, Leeds, and a few other enterprising firms.

The construction of these furnaces has been still further improved lately by the application of horizontal regenerators, to save deep excavations, and

by other arrangements, whereby the first cost is diminished, and the working of the furnace facilitated.

Table No. 4.

Percentage of Carbon and Silicon contained in various kinds of cast and wrought iron and steel.

Description.	Carbon.	Silicon.	Authority.
	per cent.	per cent.	
Spiegeleisen (New Jersey, U. S.)	6·900	0·100	Henry.
„ (German)	5·440	0·179	Schafhäutl.
„ (Müsen)	4·323	0·997	Fresenius.
Löfsta pig iron (Dannemora, Sweden)	4·809	0·176	Henry.
Grey pig iron No. 1. (Tow Law)	2·795	4·414	Riley.
Grey pig iron No. 1. (Acadian Iron Co.)	3·500	4·840	Tookey.
Grey Foundry pig iron No. 1. (Netherton, South Staffordshire)	3·07	1·48	Woolwich Arsenal.
Grey Foundry pig iron No. 2. Ditto, ditto	3·04	1·27	„
Grey Forge pig iron Ditto, ditto	3·12	1·16	„
Forge pig iron Ditto, ditto	3·03	0·83	„
Strong Forge pig iron Ditto, ditto	2·81	0·57	„
Grey pig iron (Dowlais)	3·14	2·16	Riley.
Mottled pig iron „	2·95	1·96	„
White pig iron „	2·84	1·21	„
Mottled pig iron (Wellingborough)	2·10	2·11	Woolwich Arsenal.
White pig iron (Blaenavon)	2·31	1·11	Percy.
Refined iron (Bromford, S. Staffordshire)	3·070	0·630	Dick.
Puddled steel, hard (Königshütte)	1·380	·006	Brauns.
„ „ mild (South Wales)	·501	·106	Parry.
Cast steel: Wootz	1·645	·042	Henry.
„ for flat files	1·2	......	A. Willis.
„ (Huntsman's) for cutters	1·0	......	„
„ for chisels	·75	......	„
„ Die steel (welding)	·74	......	„
„ Double Shear steel	·7	......	„
„ Quarry Drills	·64	......	„
„ Mason's Tools	·6	......	„
„ Spades	·32	......	„
„ Railway Tyres	32 to 27	......	„
„ Rails	26 to 24	......	„
„ Plates for Ships	·25	......	Various.
„ very mild (melted on open hearth)	·18	......	A. Willis.
Hard bar iron (South Wales)	·410	·080	Schafhäutl.
„ „ (Kloster, Sweden)	·386	·252	Henry.
„ „ (Russian)	·340	trace	„
„ „ „	·272	·062	„
Boiler plates (Russell's Hall, S. Staffordshire)	·190	·144	„
Armour „ (Weardale Iron Co.), too steely	·170	·110	Percy.
Bar iron (Löfsta, Sweden)	·087	·115	Henry.
„ (Gysinge, Sweden)	·087	·056	„
„ (Österby, Sweden)	·054	·028	„
Armour plates (Beale & Co.)	·044	·174	Percy.
„ „ (Thames Iron Co.)	·033	·160	„
„ „ (Low Moor)	·016	·122	Tookey.

Fourth Report on the Structure and Classification of the Fossil Crustacea. By Henry Woodward, *F.G.S., F.Z.S., of the British Museum.*

(Plate II.)

During the past year no new Silurian forms of Crustacea have come under my notice, save the series which I had the pleasure to exhibit at Dundee. Of these, belonging to the Order Merostomata, the following have been fully described and figured:—

a. Eurypteridæ*.

1 *Eurypterus (Pterygotus) punctatus*, Salter, sp.
2. —— *scorpioides*, sp. nov.
3. —— *obesus*, sp. nov.
4. *Pterygotus raniceps*, sp. nov.

b. Limulidæ†.

Neolimulus falcatus, sp. et gen. nov.

Perhaps the most interesting point which I have been able to determine in connexion with these Upper-Silurian forms is the occurrence of gill-plates in *Pterygotus* in precisely the same relative position as we find they occupy in *Limulus* at the present day, but differing in form. These leaf-like branchiæ occur in rows, and still exhibit their highly vascular structure, and indicate by their aspect in the fossil state their extreme tenuity.

It is very interesting to me, and I cannot but believe that it will also interest others working at the *Invertebrata*, to find the number of points which *Pterygotus* possesses in common with the *Scorpionidæ* among the *Arachnida*.

If the organs called "*combs*," which are attached to the first *thoracic* segment of *Scorpio*, be rudimentary gills, *not wholly aborted*, we have another point of analogy gained between the two‡.

That rudimentary gills existed in *Pterygotus* at the border of the segments, and in that position in which the pulmonary sacs in *Scorpio* are found, I have evidence both from the Devonian and Silurian species.

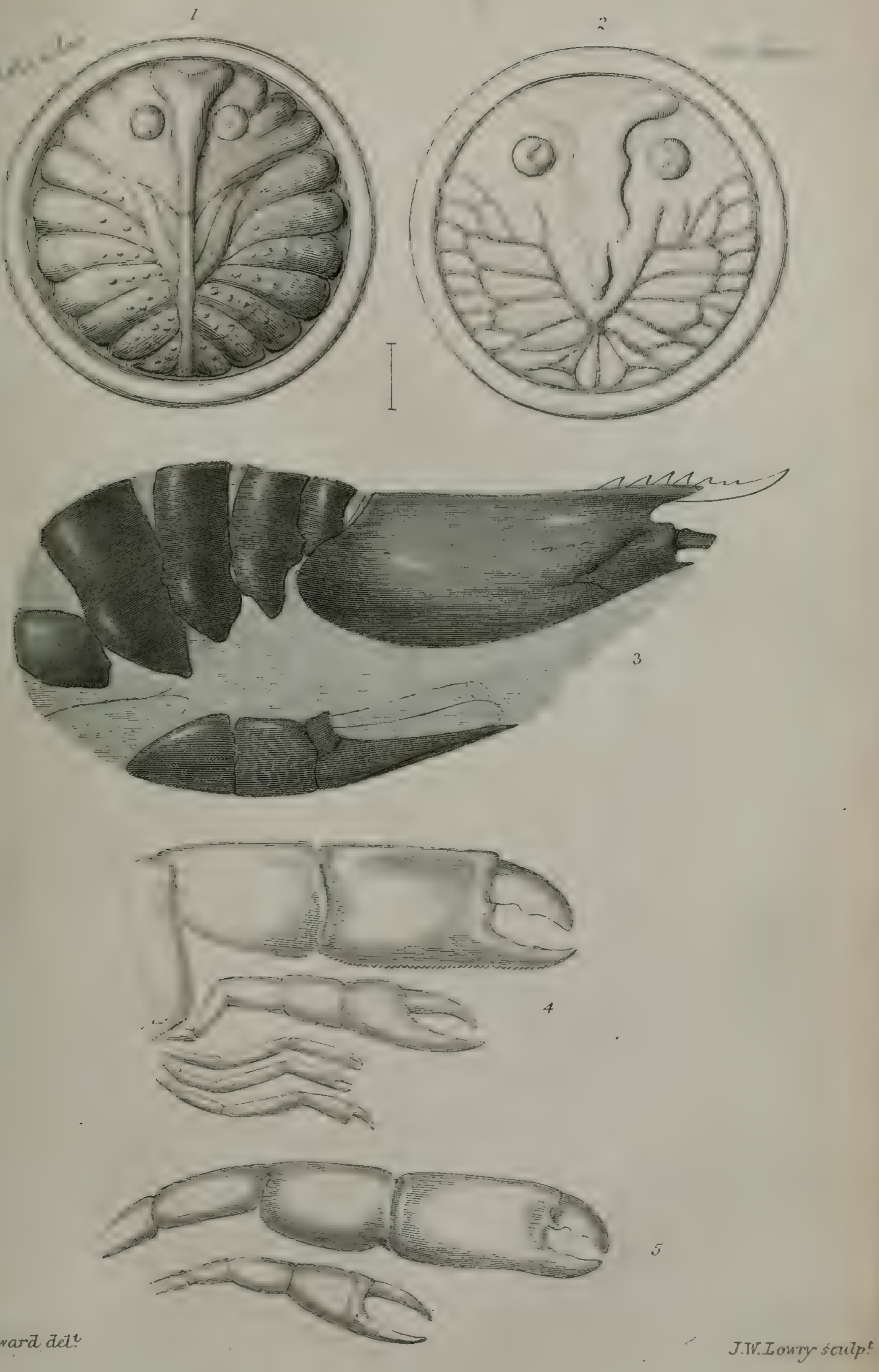
The position also of the ovaries in *Pterygotus* and *Scorpio* is the same, though in the former the opening to the sacs is double, as in *Limulus* and other Crustacea, whereas in *Scorpio* it is *externally* central as in Insects. A bilobed plate conceals the apertures in both forms. My conclusion is that there is good ground for assuming that *Pterygotus* represented, in Palæozoic time, the aquatic condition of *Scorpio*, just as the aquatic larvæ of *Libellula* represent to day the *imago* of a future season.

I have lately received specimens from the Carboniferous shales of Carluke of a new form of Crustacean allied to *Cyclus*. I was at first doubtful whether the *Cyclus radialis* of M. de Koninck, from Belgium, really represented the *Agnostus radialis* of Prof. Phillips, from the Carboniferous Limestone of Bolland, Yorkshire. I have fortunately been able to see and examine the original specimen of *Cyclus radialis* of De Koninck, and find that it does agree with the figure in Phillips's 'Geology of Yorkshire' (vol. ii. t. 22. fig. 25); but it entirely disagrees with M. de Koninck's magnified figure. I have therefore redrawn the Belgian form, and propose to figure it by the side of the new British form from Carluke. (See Plate II. figs. 1 & 2.)

* See Quart. Journn. Geol. Soc. 1868, vol. xxiv. pp. 289–294, pls. 9 & 10.

† See Geol. Mag. 1868, vol. v. p. 1, pl. 1. figs. 1 & 1*a*.

‡ I am preparing injections of recent specimens of *Scorpio* in the hope of being able to demonstrate this point certainly.



H. Woodward del.t J.W. Lowry sculp.t

British Fossil Crustacea.

Cyclus radialis (Pl. II. fig. 1) is an elegant little shield-shaped buckler 5 lines long by 4 in breadth; its general form is hemispherical, with a narrow smooth border; the shield is divided down its centre by a raised longitudinal ridge, from which radiate seven diverging ribs whose rounded ends reach the lateral and posterior border.

The anterior cephalic portion occupies about a quarter of the entire shield, and is ornamented by the spreading out of the raised central ridge, and by two subcentral rounded prominences which correspond in position to eye-spots, but are not facetted. The ribs are ornamented each with from three to five tubercles irregularly disposed over their surface.

The new form of *Cyclus* (Pl. II. fig. 2) discovered by Dr. Rankine of Carluke, in the Carboniferous shales of that place, is most remarkable in appearance, and certainly far more like a parasitical Crustacean than the *Cyclus radialis*, which certainly seems to have been furnished with a hard calcareous test. A comparison of the two, however, leaves no doubt in my mind in referring them both to one genus.

The shield is about 4 lines in diameter, and conveys the idea of an extremely thin test flattened out on the soft shale by pressure. The eye-spots occupy the same relative position as in *C. radialis*; but the divisions which represent the costæ are six, not seven in number in this species, and these anastomose together on the lateral border, and diverge, not from a median raised ridge, but a broad V-shaped central area. One is reminded by this Crustacean of the appearance of *Argulus*, *Bopyrus*, and other recent parasitic forms, and also of the disk-shaped *Discinocaris*, from which it differs, however, in the prominent eyes and costated shield.

For this new species (Plate II. fig. 2) I propose the name of *Cyclus Rankini*, after its discoverer.

In describing *Cyclus radialis*, M. de Koninck observes:—

"There is no doubt this animal should be ranged with the Crustacea, and in Milne-Edwards's order Trilobita abnormalia and battoidea, near to *Agnostus*."

M. de Koninck also thinks it probable that the body of *Cyclus* was soft and very contractile, that it was a parasite, and that the two tubercles which we have called the eyes really covered those organs—and, further, that the ribbed border protected the feet when the animal was in repose.

We must differ from M. de Koninck in referring this form to the Trilobita. If truly an adult, it must be placed near to *Apus* with the other shield-bearing Phyllopoda; if a larval form, it may have been the early stage of *Prestwichia* or some other of the Coal-measures *Limulidæ*. Nor do we think it in the least probable that the shield of *Cyclus radialis* was flexible or contractile, its original segments being completely soldered together into one piece.

Hermann von Meyer has figured a small Crustacean head-shield under the name of *Halicyne agnota*, and a second species, *H. laxa**, from the Muschelkalk of Rottweil in Germany. Goldfuss originally figured it as an *Olenus* (*O. serotinus*); afterwards it was referred to *Limulus* by Münster (Beiträge, 1841, Bd. i. t. v. f. 1). To both these conclusions Meyer demurs—to *Limulus* because no eyes are visible, and to the Trilobita because none are found older than the Carboniferous.

The form of this head-shield is extremely like that of *Agnostus*; but the *Agnostidæ* are confined to the Lower Silurian strata, between which and the

* See Palæontographica, 1847, vol. i. p. 134.

Trias are the long intervening series of Upper Silurian, Devonian, Carboniferous, and Permian formations. I consider this form may more properly be placed with *Bunodes*, *Hemiaspis*, &c. among the aberrant forms of the *Limulidæ*, of which it may possibly have been a larval state.

Among the Secondary forms of Crustacea I have described the following from British specimens during the past year.

Palinurina longipes. Lower Lias, Lyme. (Geol. Mag. 1868, vol. v. p. 260, pl. 14. fig. 5.)

Pseudoglyphea grandis. Lower Lias, Weston. (Ibid. p. 353, pl. 17. fig. 1.)

Glyphea rostrata. Lower Lias, Weston. (Ibid. p. 354, pl. 17. fig. 2.)

—— *Heeri.* Lower Lias, Lyme Regis. (Ibid. p. 355, pl. 17. fig. 3.)

—— *Tomesii.* Lower Lias, Welford Hill, Stratford-on-Avon. (Ibid. p. 356, pl. 17. fig. 4.)

I have now to notice another species, of the genus *Penæus* of Fabricius, from the Lower Lias, Northampton. This is a remarkably persistent form; and the genus is actually found now living in the Mediterranean, if Dr. Oppel's determination be correct, which I feel little doubt in endorsing.

This handsome Crustacean (see Plate II. fig. 3) was not less than $9\frac{1}{2}$ inches in length when measured along the dorsal line, the carapace being about 3 inches, and the abdomen $6\frac{1}{2}$; the rostrum was very strongly serrated as in the *Palæmonidæ*, but the serrations have been abraded in the fossil. This form most nearly resembles in size and appearance the *Penæus speciosus* of Münster, but differs slightly in the form of the border of the abdominal segments, and also in the direction of the strong and deeply forked sulcus which marks each side of the latero-anterior portion of the carapace near the base of the great antennæ. The surface of the carapace and segments was highly enamelled, some portions of which may still be observed in the fossil. I have named it *Penæus Sharpii*, after Mr. Samuel Sharp, F.G.S., who is the discoverer of the fossil.

Of the Cretaceous Crustacea two have been noticed by me, viz. a new Cirripede from the Norwich Chalk, *Pyrgoma cretacea* (Geol. Mag. vol. v. 1868, p. 258, pl. 14. figs. 1 & 2), and *Necrocarcinus tricarinatus*, from the Gault of Folkestone (ibid. p. 259, pl. 14. fig. 4).

I am now enabled to add two new species of a family not hitherto before noticed in a fossil state in Britain, the family of the *Thalassinidæ*.

This curious group contains several genera and species. Those of which we know the habits, burrow in the sand, which they readily excavate with their feet.

Although frequently found fossil, especially in the Upper Chalk of Maestricht, of France, and Bohemia, we rarely see a trace of their bodies. Even in dredging, the usual thing is to find the two fore claws only in the dredge (if any part of them is taken at all). In the fossil state it is to be also anticipated that their occurrence would be rare, as the integument of their bodies (like that of the Hermit-Crab and others which conceal themselves in foreign substances) is extremely thin, and often soft. I may compare the difference of their test to that which exists between a lady's hand encased from infancy in a kid glove, and the hand of a savage who uses his digits constantly for delving in the ground after roots. In the one, the covering membrane is thin and soft; in the other, hard and horny. One might even go further and imagine (by repeated exclusion from use) the nails would be no longer developed; certainly they are less powerful as offensive weapons. This is precisely what we find does take place in the burrowing Crustacea;

the hard and shelly epimeral pieces of the body-segments are not properly developed (as they are in the common lobster and other active *swimming* long-tailed forms), and the lobes of the tail are in like manner rudimentary. Such changes I cannot but conceive to have been the result of long habit, arising from the disuse of the organs of a part of the body, causing first their gradual reduction in size, and finally resulting in their abortion. The two new species of *Thalassinidæ* I have to notice belong to the genus *Callianassa*, hitherto characteristic of the Maestricht Chalk, and found also living in our own seas. We are now able to take it back to the Lower Greensand on the one hand, and link together the Cretaceous and Recent periods by a species in the Eocene beds of Hempstead, Isle of Wight. I have named the first *Callianassa Neocomiensis*, from the Greensand, Colin Glen, Belfast (Pl. II. fig. 5), and the second *Callianassa Batei* (after Mr. C. Spence Bate), from Hempstead Upper Marine series, Isle of Wight. (Plate II. fig. 4.)

This is a genus which should be looked out for by collectors of Upper-Chalk fossils in Norwich.

The Plates exhibited are intended for the second part of my Monograph on the fossil Merostomata, which now awaits its turn of publication. I wish to add a word here in favour of the Palæontographical Society, as deserving of support, as a means of enabling authors writing upon special branches of Palæontology to secure the publication of their researches. If more subscribers would only come forward in its aid, more authors would be enabled to make their work known, and much time would be saved. The last volume issued is an illustration of what they give for their annual guinea subscription*.

Casts of the largest of the Palæozoic Crustacea have already been prepared and coloured, and copies sent to Liverpool, Dublin, Oxford, Cambridge, Edinburgh, Glasgow, Norwich, and elsewhere, for the Museums of those cities.

EXPLANATION OF PLATE II.

Fig. 1. *Cyclus radialis*, Phillips, sp. From the Carboniferous Limestone of Bolland, Lancashire, and Visé, Belgium. Enlarged five times the natural size.

Fig. 2. *Cyclus Rankini*, sp. nov. From the Coal-shales, Carluke, Scotland. Magnified five times.

Fig. 3. *Penæus Sharpii*, sp. nov. Lower Lias, Northampton. A fourth less than the natural size (the outlined parts are restorations).

Fig. 4. *Callianassa Batei*, sp. nov. Upper Marine series, Hempstead, Isle of Wight. Natural size.

Fig. 5. *Callianassa Neocomiensis*, sp. nov. Greensand, Colin Glen, Belfast. Natural size.

First Report on the British Fossil Corals.

By P. Martin Duncan, *M.B. Lond., F.R.S., F.G.S., Sec. Geol. Soc.*

This Report consists of notes of observations made upon the Coral-faunæ described by MM. Milne-Edwards and Jules Haime in the monograph of the 'British Fossil Corals' (Palæontographical Society, 1850), of descriptions of new and unpublished species, of notices of species published by me in 1867 and 1868, and of examinations into the affinities of the forms and their geological positions.

* The last volume issued contained 45 Plates (9 of which were double quarto) and 238 4to pages of text.

The fossil Corals of the Crag, Brockenhurst beds, Eocene deposits, Upper and Lower White Chalk strata, Upper Greensand and Red Chalk rock of Hunstanton are considered, and also those of the Rhætic beds and of the great Liassic series.

The fossil Corals of the Lias have been described by me and published in two parts by the Palæontographical Society during the last twelve months. This great fauna, with the exception of one species, is new to Great Britain, and has been illustrated in seventeen plates.

The fossil Corals of the Red Chalk of Hunstanton have just been lithographed in one plate; and those from the interesting Tertiary deposit at Brockenhurst have been already published and illustrated (1866).

The Report dwells fully upon these three new faunæ. The species described by MM. Milne-Edwards and Jules Haime, from the strata whose Corals are noticed here, are forty-three in number.

I am glad to add notices of 115 species new to Great Britain, twenty-five of the species having been described in the Coral-faunæ of the Continent.

LIST.

New Eocene species......	12	Described elsewhere	2
,, Brockenhurst	11	,, ,, ...	2
,, Upper Chalk	10	,, ,, ...	1
,, Upper Greensand ..	4	,, ,, ...	2
,, Hunstanton Red rock	2	,, ,, ...	2
Middle Lias............	2	,, ,, ...	0
Zone of Amm. raricostatus / ,, ,, Bucklandi..	10	,, ,, ...	2
,, ,, angulatus ..	37	,, ,, ...	13
,, ,, planorbis..	2	,, ,, ...	1
Total new species....	90		25
	25		
	115		

Species described by MM. Milne-Edwards and Jules Haime, 43. Total species, 158.

The labour of passing so many forms under review, and of superintending twenty-six plates published by the Palæontographical Society, two plates in the Philosophical Transactions, and one in the Journal of the Geological Society, may perhaps be explanatory of the impossibility of my concluding the Report on the Cretaceous Coral-fauna.

The new species from the Gault, however, have been lithographed but not published; but those from the Upper Greensand and Neocomian have not yet been drawn.

There remains for a future Report the description of the fossil Corals of the Gault, Lower Greensand, and of the Oolitic rocks.

The vast Coral-remains of the Palæozoic age have not been alluded to in this Report; and although I have had the advantage of Mr. Thomson's valuable skill in producing sections of Carboniferous corals, and also of investigating large series of Devonian and Silurian forms, I can only assert that, before any satisfactory communication on these early Zoantharia can be written, much time must be occupied and much labour be undergone *.

* The Grant of £50 for reporting on the British Fossil Corals has been spent.

REPORT.

The researches of Darwin, Dana, and others have been so long before the scientific world, that the external physical conditions accompanying Coral-life are universally well understood. The physico-chemical changes which take place in dead corals and influence their future fossil condition have been described; and it is most reasonable to assert that the representatives of the existing Coral-faunæ flourished under the same kind of conditions, and were subjected to the same prefossil incidents and changes.

Corals are either aggregated in reefs or distributed sparely over the sea-bottom. In the strata of nearly every formation, somewhere or other, aggregations of corals are found, either in great banks, or as distinct reefs hanging on to the older rocks; moreover sparely distributed solitary or simple forms are universal.

In the Caribbean Sea, the Indo-Pacific, the Great Ocean, the China seas, aggregations occur and the species flourish in comparatively shallow water. In the deep water from 50 to 200 fathoms, between reefs, simple and sparely distributed species occur; and in other seas, where there are no reefs, the sea-bottom from about 50 to 200 fathoms supports larger or smaller simple and a few compound forms.

The Mediterranean, the Atlantic off the Spanish coast, the Bay of Biscay, the South-west British sea, and especially the seas between Unst and Norway are characterized by numerous simple Madreporaria and a few compound forms.

This geographical and bathymetrical distribution must influence us in reasoning geologically upon the presence of corals in strata; and a tropical climate must not be of necessity inferred from the discovery even of fine specimens.

Corals cannot migrate except by the floating away of their ova; and very slight alterations in the very definite physical conditions destroy the parent stock as well as the ova. It is not surprising therefore to find the species very much restricted in their vertical range in strata. Recent species vary greatly under slight modifications of the sea-depth, force of wave, and purity of sea-water; and it is found that corresponding variations occurred in every age, the minute structural differences repeated over and over again in specimens from the same deposits having clearly a genetic relation to a definite type. As there are now geographical provinces of corals differing in genera, species, and in physical peculiarity, so in every formation down to the Lower Silurian there are evidences of areas characterized by reefs or by simple and solitary species, and the species of distant localities were, as now, different, peculiar, and occasionally identical. From those early days there have been opportunities for the migration of distant species by their ova; and it is found that the fossil species peculiar to a certain geological horizon in one part of the world are often represented by closely allied species, varieties, or identical forms in higher or lower horizons in other parts. Some few forms are very persistent; and those which have lasted through the Tertiary ages into the present have a great geographical range, just as those which had a great vertical range in older deposits had also a great horizontal area.

It is necessary, in considering the relative ages and contemporaneity of coral species, to remember that a coral reef on the side of a precipitous submerged mountain-top had its débris carried down the abyss for ages, and that this is enormous in amount.

It must be remembered that in the course of time the distance between

the bottom of the reef and the top of the detritus will decrease very sensibly, and that any gradual elevation of the reef above the sea, producing its destruction, would be accompanied by a more rapid descent of débris. In after ages the upper and stony deposit would perchance be considered of different age from the marly and fine sediment below. Again, deep seas creeping over littoral areas and then over the land during the gradual subsidence of great areas would bring simple corals over littoral and terrestrial remains, the species all being really contemporaneous. On the other hand, a long-continued subsidence would equally tend to the increase of the reef and of the deep-water sediment. After the lowering of the area had been destructive to the reef, and no more detritus could fall, the usual ooze of the deep sea would gradually invade all. These suggestions will perhaps render the occurrence of large coralliferous deposits in certain strata only, in large areas of formations, more comprehensible, and will tend to the belief that when coralliferous deposits occur at the base of a great series of uncoralliferous strata (and this is often the case) the idea of contemporaneity is not overcome by the evident succession of the deposits.

The relation between such faunæ as the St.-Cassian and South Wales Lower Lias of the zone of *Ammonites angulatus* is evident; but the intermediate faunæ of Azzarola and of the lowest zones of the Lias on the Continent are less closely allied to the Welsh fauna. Again, the fauna of the Welsh Lower Lias is more closely allied to the Lower Oolitic Coral-fauna of England than are the Coral-faunæ of the zones of *A. Bucklandi*, *A. raricostatus*, and of the Middle and Upper Lias.

How interesting is the affinity between the Coral-fauna of Gosau and the Miocene Coral-fauna of the Caribbean area! yet the British Chalk hardly represents any part of the Gosau fauna, and our Eocene fauna has no resemblance to it. These considerations tend to prove how vast and complicated the gradual migrations must have been, even of animals which could only live under very definite and limited conditions, how really contemporaneous were the species entombed in vast consecutive deposits, how complicated the relations of the fauna have ever been, and how clearly the absence of corals from strata does not prove their absence in adjoining and equivalent areas. The notion that successive new creations of corals followed repeated destructions of faunæ is not supported by a single fact; on the contrary, all the evidence disproves it. The amount of individual variation, of gradual structural changes, and of decided variation amongst the Madreporaria is not without significance; and the examination of large series of forms from all parts of the world, and from consecutive formations, impresses the belief in the continuous evolution of new forms by variation from the old during the whole of the Coral ages.

Fossil Corals from the Crag.

The following authors have written upon this subject:—Searles Wood, Ann. & Mag. Nat. Hist. 1844, vol. xiii. p. 12. Lonsdale, Searles Wood's Catalogue, Ann. & Mag. Nat. Hist. 1844. Milne-Edwards and Jules Haime, "Mém. sur les Astræides," Comptes Rendus de l'Acad. des Sciences, vol. xxvii. p. 496 (1868); "Monog. des Turbinolides," Ann. des Sciences Naturelles, 3rd ser. vol. ix. (1848); Hist. Nat. des Corall. 1857, Paris. R. C. Taylor, Mag. Nat. Hist. 1830, vol. iii. p. 272. G. de Fromentel, 'Introd. à l'Etude des Polyp. Foss.' 1858.

The Sclerodermic Zoantharia, or true Madreporaria, are rarely found in any of the Crags. Bryozoa abound, and thus gave the term "Coralline" to

the Crag. As a general rule, the most preservable and commonest of the true corals are not found in recent seas with Bryozoa; but certain forms inhabiting the sea-bottom from the lowest spring-tide level to 200 or more fathoms are brought up by the dredge with Bryozoa. These forms are strongly represented in the Crag Coral-fauna.

List of Crag Species.

Sphenotrochus intermedius, *Münster*, sp.	Cryptangia Woodii, *Ed. & H.*
Flabellum Woodii, *Ed. & H.*	Balanophyllia calyculus, *Wood.*

Sphenotrochus intermedius is found in the Coralline Crag and in the Red Crag of England, and it has been found in the Antwerp Crag. The genus still exists, and is represented in the south-western and western British and Irish seas.

Sphenotrochus M'Andrewanus, Ed. & H., the *Turbinolia Milletiana* of William Thompson, from Cornwall and Arran, is closely allied to the Crag species; and it is very evident, from the variability of these simple corals, that *Sphenotrochus Milletianus* (Defrance, sp.) of the Anjou and Touraine Miocene, *Sphenotrochus intermedius*, and *Sphenotrochus M'Andrewanus* have descended from one type, and that they have been slightly modified to meet the changes in the external conditions in the later Tertiary and recent seas. Probably these Crag and recent species should be considered varieties of the Miocene form. My researches in the Australian Tertiary Coral-fauna have brought two species of *Sphenotrochus* to light; but they are only remotely allied to the British species.

The alliance between *Flabellum Woodii* and *F. Roissyanum* of Dax and Malaga, and *F. cristatum* of the Bolderberg, is not close; and the affinity between the British Crag species and the living *F. anthophyllum*, Ehrenberg, of the Mediterranean and Spanish coast, and perhaps from our north-east seas, is slight. *Flabellum Woodii* is closely allied to *F. subturbinatum*, Ed. and H., of the Miocene of Plaisance, and *F. Gallapagense*, from the Gallapagos Miocene. *F. Woodii* is found in the Coralline Crag.

Cryptangia Woodii, Ed. & H.—This genus is extinct, and the second species of it is a form very like the Crag species; it is from the Faluns, and, like the Crag species, is imbedded in a Cellepore. The septal arrangement of the species is rather abnormal, and there is an evident tendency to revert to some old type in which the quaternary arrangement prevailed. The genus is closely allied to *Rhizangia* and to *Cylicia*. The first of these is extinct, and flourished in the Lower Chalk of Gosau, in the Eocene, and in the Miocene; and the last is recent, its species living in the South-African and Australian seas.

Balanophyllia calyculus, Wood, is represented in the Southern British seas by *B. regia*, Gosse, to which it is closely allied. The Mediterranean species is not closely allied; and the same may be said for the Cape-of-Good-Hope *B. capensis*, Verrill, and the Miocene *B. cylindrica*. The species is found in the Red Crag, and the specimens are usually very badly preserved about the calice. The genus is fully noticed in the report on the Fossil Corals of the Brockenhurst beds.

It will thus appear that three out of the four genera of Crag corals are represented in the existing seas of our coasts by more or less closely allied species. One genus is extinct.

The fine *Stephanophyllia Nysti* of the Black Crag of Antwerp is not found in the British Crags.

Judging from the conditions surrounding the existing species and their allies, it might be asserted that no very great bathymetrical or climatal changes have taken place between the deposit of the Crag and the present time. The intervention of a long glacial period is not proved by the study of the corals. But doubtless during that period migration to deep water or to the south occurred. When the cold period was succeeded by more temperate times a return of the fauna took place; and it must be remembered that two opportunities at least were thus given for variation in form.

Fossil Corals from Brockenhurst.

Lower Oligocene.

Before 1866 no species of corals were known to exist in any beds between the top of the Barton series of the Eocene and the base of the "Crag." I published in that year, in the Supplement to the British Fossil Corals, Palæontographical Society's vol. for 1865, descriptions of thirteen species of corals from Brockenhurst in Hampshire. The species were, with the exception of two, new to science, and indicated very different external conditions to those prevailing at the time of the deposition of the Bracklesham and Barton corals. Moreover the two species which had been described from foreign sources also indicated a very different state of things from those favourable to the life of the tiny simple *Turbinoliæ* of the London Clay and of the Barton series.

The facies of the whole collection was clearly intermediate between the Eocene and the Falunian coral-faunæ. The species were collected from beds which are distinctly represented in White Cliff Bay, and which belong to the Middle Headon series.

Overlying freshwater remains (the Lower Headon), it is evident that great marine and terrestrial changes had occurred subsequently to the estuarine conditions prevailing towards the end of the deposition of the Barton series. The genera of the corals discovered at Brockenhurst prove that the conditions inseparable from a coral-reef succeeded those favourable to the development of estuarine and freshwater species of mollusca. The existing species of such genera as *Madrepora* and *Solenastræa* are reef-dwellers, and *Axopora* and *Litharæa* are represented in modern reefs by *Pocillopora* and *Porites.* Such genera as *Balanophyllia* and *Lobopsammia* were and are dwellers in from 20 to 100 or more fathoms, and are found in the deeper water, close to the reefs. A corresponding succession occurs in North Germany, and deep seams of fossil wood are covered with marine deposits of the same relative age as the marine bed at Brockenhurst. Both the marine deposits are covered with greater or less depths of sands and gravels. The molluscan fauna of Brockenhurst has much in common with those of the North German Lower Oligocene deposits superimposed on the fossil-wood seams of Magdeburg, Bernsberg, Aschersleben, Egeln, Helmstedt, and Latdorf; and the British as well as the German deposits are moreover the equivalents of the "Tongrien Inférieur."

The palæontology of the deposits has been sufficiently studied to determine the necessity of their separation in classificatory geology from the Eocene and Miocene formations. As yet no satisfactory alliances have been determined to exist between the Oligocene coral-fauna of North Germany and that of Brockenhurst. But inasmuch as the mollusca are closely allied, there is a great probability of the deep-water, oceanic, and reef tracts having been to the west of the North German littoral tracts.

List of the Species.

1. Solenastræa cellulosa, *Duncan.*
2. —— Kœneni, *Duncan.*
3. —— Reussi, *Duncan.*
4. —— gemmans, *Duncan.*
5. Beyrichi, *Duncan.*
6. —— granulata, *Duncan.*
7. Balanophyllia granulata, *Duncan.*
8. Lobopsammia cariosa, *Goldfuss*, sp.
9. Axopora Michelini, *Duncan.*
10. Litharæa Brockenhursti, *Duncan.*
11. Madrepora Anglica, *Duncan.*
12. —— Römeri, *Duncan.*
13. —— Solanderi, *Defrance.*

The species of the genus *Solenastræa* from Brockenhurst form a very interesting series, which might almost be made a subgenus. The high septal number in conjunction with the highly inclined endotheca and the defective columella characterize the group. The species described by Reuss from the Castelgomberto district, and those from Ghent and Touraine by MM. Milne-Edwards and Jules Haime, are very distinct from the Brockenhurst species. Those I have published in my 'West-Indian Fossil Corals,' and a species noticed by Michelotti and Duchassaing, from St. Thomas's, are equally remotely allied to the British forms.

The recent *Solenastrææ* are world-wide—the Red Sea, the Indian Ocean, and the Caribbean Sea being their favourite localities.

The *Madreporæ* from Brockenhurst are very interesting species, for fossil forms of the genus are very rare. *Madrepora Solanderi*, Defrance, was known as a form from Anvert and Valmondois; but it appears to me that the correct geological age of the deposit whence it and another coral (also common to the Brockenhurst, viz. *Lobopsammia cariosa*) came is not free from doubt. It is not improbable that they are true Oligocene corals, especially as the last-named species is identical with *Lobopsammia dilatata*, Römer, from Latdorf.

Madrepora Anglica is a grand form, with a great trunk and short branches, equalling in size any of the most luxuriant recent species. It is allied to *Madrepora crassa*, Ed. & H., from the Pacific and Southern oceans. The genus comprehends nearly 100 species now flourishing; but the fossil forms are only eight in number. The recent species are found, for the most part, in the boiling surf of the reef, in every part of the globe where the conditions for reefs exist.

Axopora is a genus which has absorbed the genus *Holaræa*. The species have very rudimentary septa, enormous columellæ, well developed tabulæ, and a reticulate cœnenchyma. The species are found in the Eocene of Great Britain and France, and at Brockenhurst, and they are all closely allied.

Litharæa Brockenhursti is remotely allied to the species from the Bracklesham beds and the French and the Javan tertiaries. The genus is extinct; but the Brockenhurst species, although not the latest in geological age, points to *Goniophora*, a large recent genus of Pacific and Red-Sea corals.

The species of *Balanophyllia* from Brockenhurst, like that from Bracklesham, has no epitheca, but its large base, distinct costæ, and very granular surface render it easily distinguishable. Reuss, F. Römer, and Philippi have described species from the Lower Marine Sand of Weinheim and Latdorf; but they are not closely allied to the species under consideration.

As the genus is present in the whole of the Cainozoic coralliferous beds of Great Britain, and is represented in the existing South British and Mediterranean seas, the following Table may be useful concerning its divisions.

Balanophyllia.

Subgenus 1. Corallites with broad bases.

Balanophyllia desmophyllum, *Lonsdale*, sp.	Bracklesham.	Eocene.
—— geniculata, *D'Archiac*, sp.	Port des Basques.	„
—— tenuistriata, *Ed. & H.*	Paris basin.	„
—— granulata, *Duncan*	Brockenhurst.	Oligocene.
—— cylindrica, *Michelotti*, sp.	Turin and Verona.	Miocene.
—— subcylindrica, *Philippi*, sp.	Sicily.	„
—— Italica, *Michelin*, sp.	Astesan.	Pliocene (recent).
—— calyculus, *Wood*	Crag.	Pliocene.
—— capensis, *Verrill*	Cape of Good Hope.	Recent.
—— verrucaria, *Pallas*, sp.	Mediterranean.	„
—— Cumingii, *Ed. & H.*	Philippines.	„
—— regia, *Gosse*	South Britain.	„
—— Bairdiana, *Ed. & H.*	Unknown.	„

Subgenus 2. Corallites more or less pedicellate.

—— Gravesi, *Michelin*, sp.	Henouville (Oise).	Eocene.
—— sinuata, —— inæquidens, —— fascicularis, } *Reuss*	Weinheim.	Oligocene.
—— prælonga, *Michelotti*, sp.	Turin.	Miocene.
—— Australiensis, *Duncan*	South Australia.	Miocene?
—— ineplaris, *Seguenza*	Sicily.	Pliocene.

Fossil Corals from the British Eocene Formation.

The following authors have written upon this subject:—Fleming, 'Hist. of British Animals,' 1828. Milne-Edwards and Jules Haime, *op. cit.* Lonsdale, in Dixon's 'Geology of Sussex.' J. de Carle Sowerby, Trans. Geol. Soc. vol. v. p. 136 (1834). J. S. Bowerbank, Mag. Nat. Hist. 1840. Wetherell, Trans. Geol. Soc. 2nd ser. vol. v. (1834).

The labours of these naturalists and palæontologists were collected in the great monograph of the 'British Fossil Corals' by

M. Milne-Edwards and Jules Haime, and by P. Martin Duncan, Supp. Mon. Brit. Foss. Corals, Palæontograph. Soc. 1866, part 1, Tertiary.

In the monograph last named in the list, thirteen species were added to those noticed in the previously published monograph by MM. Milne-Edwards and Jules Haime. The following is a complete summary of the Eocene species.

1. Turbinolia sulcata, *Lamarck.*
2. —— Dixoni, *Ed. & H.*
3. —— Bowerbankii, *Ed. & H.*
4. —— Fredericiana, *Ed. & H.*
5. —— humilis, *Ed. & H.*
6. —— minor, *Ed. & H.*
7. —— firma, *Ed. & H.*
8. —— Prestwichii, *Ed. & H.*
9. —— affinis, *Duncan.*
10. —— exarata, *Duncan.*
11. —— Forbesi, *Duncan.*
12. Leptocyathus elegans, *Ed. & H.*
13. Trochocyathus sinuosus, *Brongniart*, sp.
14. —— Austeni, *Duncan.*
15. Trochocyathus insignis, *Duncan.*
16. Paracyathus crassus, *Ed. & H.*
17. —— caryophyllus, *Lamarck*, sp.
18. —— brevis, *Lamarck*, sp,
19. —— Haimei, *Duncan.*
20. —— cylindricus, *Duncan.*
21. Dasmia Sowerbyi, *Ed. & H.*
22. Oculina conferta, *Ed. & H.*
23. —— incrustans, *Duncan.*
24. —— Wetherelli, *Duncan.*
25. Diplohelia papillosa, *Ed. & H.*
26. Stylocœnia emarciata, *Lamarck*, sp.
27. —— monticularia, *Schweigger*, sp.
28. Astrocœnia pulchella, *Ed. & H.*

29. Stephanophyllia discoides, *Ed. & H.*
30. Balanophyllia desmophyllum, *Lonsdale*, sp.
31. Dendrophyllia elegans, *Duncan.*
32. —— dendrophylloides, *Lonsdale.*
33. Stereopsammia humilis, *Ed. & H.*
34. Dendracis Lonsdalei, *Duncan.*
35. Porites panicea, *Lonsdale.*
36. Litharæa Websteri, *Bowerbank*, sp.
37. Axopora Forbesi, *Duncan.*
38. —— Parisiensis, *Michelin.*

Notice of the Species.

Turbinolia sulcata, Lamarck, is found in the Eocene deposits at Grignon, Hauteville, and Ghent, and is not found, I believe, in higher beds than the Bracklesham in England. The other species are purely British. *T. Prestwichii*, Ed. & H., is probably the oldest form, and *T. sulcata* and *T. Dixoni* are next in age. The remaining species come from the Barton beds. With the exception of the occurrence of *T. sulcata* in the Parisian Eocene, there is little to connect these Turbinoliæ with others. The genus is not represented in the great Nummulitic coral-fauna of the South of France, the North of Italy, or of Sindh. A species is found in the Eocene of Alabama; and three species, characterized by very bad specimens, were determined from forms found in the Lower Oligocene deposits of Germany. The genus is extinct.

The genus *Leptocyathus* is one of those artificial groups which surround the great genus *Trochocyathus*. It is closely allied to *Stephanocyathus*, Seguenza; and indeed the only distinction between these two genera is the distribution of the pali before certain septa. Doubtless some further information will enable those interested in the classification of the Zoantharia to make the genera *Leptocyathus* and *Stephanocyathus* mere subgenera of *Trochocyathus*. *L. elegans* is a very beautiful form; and the structure of its base is a curious instance of symmetry and simplicity of structure, producing in a coral which doubtless was a dweller in deepish water and on an oozy bottom, great perfection of ornamentation.

There is a second species, *L. Atalayensis*, D'Archiac, sp., from the Eocene of Biarritz; but there is some doubt about its genus.

The *Trochocyathi* of the British Eocene are insignificant species of the great genus which is so fully represented in the Sindhian and European Nummulitic series. I have noticed in my 'Supplement to the British Fossil Corals,' Part I., that it is doubtful if *T. sinuosus* was ever found in England, and I have described two new species.

One of these, *T. Austeni*, Duncan, is the representative in the Bracklesham deposits of *T. elongatus*, Ed. & H., of the Eocene of Quartier-du-Vit (Basses Alpes); but *T. insignis*, Duncan, so readily distinguishable by its costal ornamentation and wavy spino-granulose septa, is very solitary as regards its affinities. The *Trochocyathi* commenced in the Jurassic period, culminated in the Miocene, and are extinct, being represented by the *Caryophylliæ* of the Pliocene and recent coral-faunæ.

There are several genera of perforate corals in the British Eocene. Four genera of these belong to the *Eupsammidæ*, one to the *Turbinarinæ*, and two to the *Poritidæ*.

The Eupsammian genera are:—

Stephanophyllia.
Balanophyllia.
Dendrophyllia.
Stereopsammia.

The *Stephanophylliæ* are Cyclolitoid *Eupsammidæ*, and range from the White Chalk to the Pliocene.

The Cretaceous species form a group readily distinguished from the Ter-

tiary forms; and these have a calicular and columellary structure which forms them into a subgroup.

The Eocene species is distantly allied to *S. elegans* from the Miocene of Tortona. The genus is extinct.

The *Balanophyllia*, from the Bracklesham beds, is readily distinguished from the Crag species by its having no epitheca. This is one of the oldest species of the genus, whose species are found also in the Paris Eocene, and in the Nummulitic strata of Port-des-Basques. The recent species are British, South African, and Pacific (20 to 80 fathoms).

The new species, *Dendrophyllia elegans*, nobis, is one of the most beautiful corals ever discovered. The elegant branching and gemmation, the graceful costal curvature and granulation, and the symmetrical repetition of the septal cycles render the coral an object of great interest. Its nearest ally is *D. gracilis*, Ed. & H., of the Chinese seas, a dweller in twenty-five fathoms water. The Miocene and Pliocene species of the genus are well marked; and the recent species are found in the Mediterranean Sea, in the sea off Cadiz and Madeira, and in the Chinese, Pacific, and Australian seas. The most vigorous species are from Cadiz and Madeira, *Dendrophyllia ramea* living there in twenty-five to eighty fathoms.

Stereopsammia is a genus with only one species; and this was determined from the study of a very good compound corallum in the Bracklesham beds. It is interesting to note that a genus appeared in the Upper Sicilian Tertiaries (and has many species in the Australian, New-Zealand, and Chinese seas, besides some off Panama and in the Pacific coral-sea, &c.) which is closely allied to *Stereopsammia*, for its only distinction is the existence of a columella in its species. Both the genera are very erratic members of their subfamily, for the peculiar Eupsammian direction of the septa is not noticed either in *Stereopsammia* or in *Cœnopsammia*.

The aporose condition of the lower part of the corallites of *Stereopsammia*, and their perforated calicular ends, taken into consideration with the peculiarity of the septal direction, prove that the genus links the *Eupsamminæ* amongst the perforate corals with the Aporosa.

The genus *Dendracis* has hitherto been little known. MM. Milne-Edwards and Jules Haime described the first species, out of the *Madrepora Gervilii* of Defrance, from the Hauteville beds; but no species was known to be of British growth. Whilst examining the Dixon collection in the British Museum, I found a species, *D. Lonsdalei*, nobis. Very recently Reusshas described:—*D. seriata*, Castelgomberto; *D. mammillosa*, Castelgomberto; *D. Haidingeri*, Oberburg and Java; and *D. nodosa*, Oberburg. D'Achiardi has also described a species from the Castelgomberto district.

Lonsdale was correct in his diagnosis of his *Porites panicea*; and it is a most interesting species, for it is a true *Porites* and a perforate coral. The form has its septa less spiculate and more lamellate than is usual in the *Porites*, moreover the cœnenchyma is very decided. This Eocene species has thus characteristics of the genera *Porites*, *Astræopora*, and *Litharæa*.

Reuss has described *Porites nummulitica*, Oberburg; *P. minuta*, Castelgomberto; *P. incrassata*, Java, tertiary. This last species is closely allied to *Porites panicea*.

Some years since, I described a *Porites* from the Lower (Hippurite) Limestone of Jamaica. Our knowledge of the genus, therefore, extends from the Lower Chalk to the present day. The Miocene forms and the recent are the most numerous. *Astræopora panicea*, Ed. & H., must give way to the original species, *Porites panicea*, Lonsdale. The *Astræoporæ* flourished in the Castel-

gomberto deposits. The genera *Axopora* and *Litharæa* have been noticed in the report on the Brockenhurst corals. The first genus represented the *Milleporidæ* in the Eocene.

The five species of *Paracyathus* from the British Eocene are:—

Paracyathus crassus, *Ed. & H.*
—— caryophyllus, *Lonsdale*, sp.
—— brevis, *Ed. & H.*
Paracyathus Haimei, *Duncan.*
—— cylindricus, *Duncan.*

P. caryophyllus is found in the Jamaican Eocene, and is closely allied to *P. cylindricus. P. crassus* and *P. Haimei* are also allied.

It is doubtful whether the genus should be considered more than a subgenus of the great genus *Trochocyathus.* There are recent species in the Mediterranean and in the West Indies. They are found at a depth of from fifteen to eighty fathoms.

M. de Fromentel has described a species of the extraordinary Eocene genus *Dasmia,* from the Neocomian of St. Dizier. The genus stands by itself, unless the opinion of MM. Milne-Edwards and Jules Haime be admitted to be correct, viz. that each lamina is a septum. To carry this opinion further would place the genus amongst the *Eupsammidæ.*

The *Oculinidæ* are represented in the British Eocene by two genera and four species.

Oculina conferta, *Ed. & H.*
—— incrustans, *Duncan.*
Oculina Wetherelli, *Duncan.*
Diplohelia papillosa, *Ed. & H.*

The three species of *Oculina* belong to a subdivision of the genus in which the calices are distributed without order, the costal striæ being rudimentary or absent. *Oculina conferta* has some analogy with *Oculina Halensis,* Duncan, from the nummulitic limestone of Sindh; but the Sindhian coral has its calices arranged in a serial order. The genus flourished in the Miocene and Pliocene periods, and is represented in almost every coralliferous sea by species living either in tolerably deep water or at a very great depth.

Diplohelia is an extinct genus, and characterizes Tertiary deposits. There is a species, *D. raristella,* Defrance, sp., in the Eocene of Paris and Biarritz. In the corresponding deposits of Lacken there is *D. multistellata,* Galeotti, sp. The Miocene species from the Sicilian Tertiaries have lately been described by Seguenza; and *D. reflexa,* Michelotti, sp., is from Superga. The great devolopment of the columella in *Diplohelia* separates the genus from its nearest ally *Astrohelia,* whose species are Miocene forms from the Faluns and from Maryland. The transition between the genera is through *Astrohelia Lesueuri,* Ed. & H., from the American Walnut-Hill Miocene. This species has a small, lax, and spongy columella, and its closest affinity is with the *Diplohelia* with costal striæ. M. Milne-Edwards remarks that *Astrohelia* (thus united with *Diplohelia*) is a passage from between the *Oculinidæ* and the *Astræidæ,* particularly in relation to the *Cladangiæ,* a Miocene genus. The affinity between *Cladangia* and the recent *Astranginæ* is evident.

The genera *Stylocœnia* and *Astrocœnia* have been removed from the *Eusmilinæ* to the *Astræinæ* in consequence of the discovery that their septa are dentate.

Stylocœnia emarciata has an immense geological range. It characterizes the Eocene of Jamaica, Sindh, Italy, France, and England.

S. monticularia is common to the French and British Eocene beds. (See remarks on the genus in the report on the fossil corals of the Lias.)

Astrocœnia is a very important secondary genus; its peculiarities are fully discussed in the Report on the Fossil Corals of the Lias. There are three species in the Eocene, but only one is British. Reuss has lately described

two species from the Castelgomberto district. The genus became extinct in the Miocene age.

The smaller Heliastræans and Astræans appear to represent these genera in the recent coral-faunæ.

It may be assumed, from our knowledge of the habits of the representatives of the Eocene species in the existing seas, that the bulk of the fauna lived on oozy sea-bottoms, at a depth of from 10 to 100 fathoms. Such a sea (as regards its depth, bottom, and magnitude, but not as regards its temperature) as has been dredged off Unst, or the Southern China Sea, where there are no reefs, might resemble that which contained the old *Turbinoliæ*, *Trochocyathi*, *Paracyathi*, *Oculinæ*, *Stephanophylliæ*, *Balanophylliæ*, *Dendrophylliæ*, and *Stereopsammiæ*.

The genera *Stylocœnia*, *Astrocœnia*, *Dendracis*, *Porites*, *Litharæa*, and *Axopora* were probably located on small reefs, or in shallower water than the others. The fauna, as a whole, is insignificant, and bears a very feeble relation to the magnificent Eocene Coral-fauna of Castelgomberto, the South of France, and Sindh. These were the coral-tracts of the period, and were full of great reefs, whose corals are represented now-a-days by large and quickly growing species.

The immense break between the Upper Chalk and the British coralliferous Eocene deposits is proved by the total difference of their coral-faunæ.

The scanty relationship between the British Eocene and Lower Oligocene coral-faunæ has already been noticed. Part of the British Eocene coral-fauna is represented by species now living in the British, Spanish, and Mediterranean seas, and the rest by species in the Pacific and East-Indian oceans. The slight affinity between the British Eocene and the recent West-Indian coral-faunæ is therefore worthy of notice.

Fossil Corals from the Upper and Lower White Chalk of Great Britain.

The following authors have written upon this subject:—MM. Milne-Edwards and Jules Haime, *op. cit.* Lonsdale in Dixon's 'Geology of Sussex.' Parkinson, 'Organic Remains of a Former World.' Mantell, 'Geology of Sussex,' and Trans. Geol. Soc. 2nd ser. vol. iii. Fleming, 'British Animals,' 1828. Phillips's 'Illustrations of the Geology of Yorkshire,' pt. 1, 1829. S. Woodward, 'Synopt. Tab. Brit. Org. Remains,' 1830. R. C. Taylor in Mag. Nat. Hist. vol. iii. p. 271 (1830).

MM. Milne-Edwards and Jules Haime noticed and described nine species from these formations. One of these species had been previously described by Mantell, and another by Reuss; but seven species were added to our British fauna through the industry of the great French zoophytologists.

During the last few months I have thoroughly examined the specimens offered to me, and those which had been studied by MM. Milne-Edwards and Jules Haime, Lonsdale, and Mantell. I can add ten new species to the list of the corals from the White Chalk, and five good varieties of formerly known species. It is necessary also to admit a species of Mr. Lonsdale's, and to uppress one of MM. Milne-Edwards and Jules Haime.

Corals from the Upper and Lower White Chalk.

1. Caryophyllia cylindracea, *Reuss*, sp.*
2. —— Lonsdalei, *Duncan*†.
3. —— Tennanti, *Duncan*†.
4. Onchotrochus serpentinus. *Duncan* †.
5. Trochosmilia laxa, *Ed. & H.*, sp. and varieties 1, 2, 3 ‡.

* Synonym *Cyathina lævigata*.

† Species not hitherto described.

‡ Varieties or subspecies not hitherto described.

6. Trochosmilia cornucopiæ, *Duncan* *.
7. —— Wiltshiri, *Duncan* *.
8. —— Woodwardi, *Duncan* *.
9. —— granulata, *Duncan* *.
10. —— cylindracea, *Duncan* *.
11. Parasmilia centralis, *Mantell*, sp., varieties 1, 2.
12. —— cylindrica, *Ed. & H.*
13. Parasmilia Fittoni, *Ed. & H.*†
14. —— serpentina, *Ed. & H.*
15. —— monilis, *Duncan* *.
16. —— granulata, *Duncan* *.
17. Diblasus Gravensis, *Lonsdale.*
18. Synhelia Sharpeana, *Ed. & H.*‡
19. Stephanophyllia Bowerbanki, *Ed. & H.*‡

The list of species presents a remarkable assemblage of forms. The *Caryophylliæ* are represented in existing seas, especially in from low spring-tide level to 80 or 100 fathoms, in the West Indies, the Mediterranean, and in the south-east and north-east British seas. They are, with one exception (the *Caryophyllia Smythi*), always dwellers in many fathoms; and this coral is evidently a littoral variety of *C. borealis.* The *Oculinidæ* of the present day are usually found under the same conditions as the *Caryophylliæ*; and doubtless the *Parasmiliæ* and *Trochosmiliæ* were dwellers in from 10 to 100 fathoms.

There are no forms which indicate shallow waters, or anything like a reef. The fauna is essentially a deep-sea one.

The continental development of Cretaceous corals is very remarkable; and the horizon of Gosau and Martigues, probably that of our Lower White Chalk and part of the Upper Greensand, is characterized by the reef species. A more decided equivalency between the higher horizons of the Upper Chalk of the continent and the Norfolk beds has been established by the discovery of some of the species now noticed for the first time.

Family TURBINOLIDÆ.

Division CARYOPHYLLACEÆ.

MM. Milne-Edwards and Jules Haime adopted for a coral from the Upper Chalk the name of *Cyathina lævigata.* They published this name in their "Monog. des Turlinolides," Ann. des Sciences Nat. 3rd series, vol. ix. p. 20 (1848), and in their "Monograph of the Corals of the Upper Chalk," Pal. Soc. 1850. Lonsdale named the same coral *Monocarya centralis,* Dixon, 'Geol. of Sussex,' 1850, and probably *Monocarya cultrata* also.

In 1850 D'Orbigny (Prodr. de Paléont. t. ii. p. 275, 1850) gave the coral the specific name *cylindracea,* it having become evident that Reuss was the primary discoverer of the species in 1846. In his 'Kreideformation,' p. 61, pl. 14, figs. 23–30, Reuss gives the name *Anthophyllium cylindraceum.* The genus of the coral is evidently *Caryophyllia,* in the sense adopted by Charles Stokes in 1828.

MM. Milne-Edwards and Jules Haime, having all this information before them, very properly determined the generic and specific names to be *Caryophyllia cylindracea,* Reuss, sp., in their 'Hist. Nat. des Corall.' vol. ii. p. 18.

This species is very polymorphic, and the pali of some specimens are very like the outer terminations of the columellary structures in some *Parasmiliæ.* Very frequently it is hardly possible to determine which are the pali and which the ends of the columellary fasciculi. Moreover in some specimens the base is small and the costæ reach low down; whilst in others the base is normal and large, the costæ being abnormal from their length. There is a

* Species not hitherto described.

† See the remarks on the propriety of absorbing *P. Mantelli.*

M. de Fromentel has described *Caryophyllia decameris,* from Southfleet. Much experience in these species inclines me to believe the decameral arrangement he speaks of to be a monstrosity. His species has but one specimen.

‡ Lower Chalk.

new species of this genus in the Dunstable chalk, and another in the chalk of Sussex. There are thus three species of *Caryophyllia* in the Upper Chalk of England:—

1. Caryophyllia cylindracea, *Reuss*, sp.
2. —— Lonsdalei, *Duncan*.
3. Caryophyllia Tennanti, *Duncan*.

Caryophyllia Lonsdalei, Duncan.

The corallum has a large and incrusting base, and the stem is cylindro-conical and straight. There is a slight curve near the base. The calice is circular, small, not very open, and moderately deep. The columella is small, and is terminated by rod-shaped processes. The septa are slightly exsert, the primary especially. There are three complete cycles; and the septa of the higher orders of the fourth cycle are not developed in every system. The primary, secondary, and tertiary septa are very much alike. They have a wavy inner edge and are granulated. The pali are situated before the tertiary septa, and are knob-shaped, and rather flat from side to side. The costæ are nearly equal at the calicular margin, and pass downwards as flat, band-like prominences, separated by shallow intercostal grooves. They are continued to the base, but are hidden midway by an epithecal growth.

Height of the corallum $\frac{5}{6}$ inch. Breadth of the calice $\frac{1}{3}$ inch.

Locality. Dunstable.

In the collection of the Rev. T. Wiltshire.

This species is readily distinguished by its costæ, and is more closely allied to *C. cylindracea* than to any other form.

Caryophyllia Tennanti, Duncan.

The corallum has a large base, a curved cylindrical stem, and an inclined elliptical calice. It is short in relation to its broad base. The calice is open and shallow. The columella is small, and terminates in twelve knob-shaped endings to the fasciculi. The septa are unequal, and there are five incomplete cycles. The laminæ are marked with curved lines of granules, are wavy and unequal. The pali are longer than the columellary processes, are wavy, flattened, and curved. The costæ are subequal in the upper third, but are not seen below.

Height $1\frac{1}{3}$ inch. Length of calice $\frac{5}{6}$ inch.

Locality. Sussex, Upper Chalk.

In the collection of Professor Tennant, F.G.S.

This species connects the Tertiary and recent *Caryophylliæ* with those of the Cretaceous system.

Division Turbinoliaceæ.

Gen. nov. Onchotrochus.

The corallum is simple, tall, slender, rather hook-shaped or clavate, and presents evidence of irregular growth.

There is no endotheca. The costæ are rudimentary, and there is no columella. The septa are few in number. The epitheca is pellicular and striated.

The genus is somewhat allied to *Smilotrochus*, *Stylotrochus*, and very distantly to *Flabellum*.

Onchotrochus serpentinus, Duncan.

The corallum is tubulate, curved superiorly, and straight, and tapering inferiorly. There is a sudden diminution in the diameter of the upper part of the corallum. The costæ are quite rudimentary. The epitheca is marked with fine transverse striations. The septa are continuous with what appear to be rudimentary intercostal spaces. The laminæ are twelve in number;

they project into the circular calice, but are not exsert. A section proves that they are very stout even low down in the corallum.

Length of corallum 1 inch. Diameter of the calice $\frac{1}{6}$ inch.

Locality. Charlton, Kent.

In the collection of the Rev. T. Wiltshire.

This species is mimetic of *Parasmilia serpentina*, Ed. & H., from the same geological horizon, just as *Thecosmilia cylindrica* is of *Parasmilia cylindrica*. The *Stylotrochi* of the Cambridge Upper Greensand are closely allied to the Upper-Cretaceous form.

Family ASTRÆIDÆ.

Genus Trochosmilia.

Subgenus *Cœlosmilia*.

It is a great question whether *Cœlosmilia* can stand as a genus. It is impossible to separate its species from those of *Trochosmilia* by an external examination; and sections prove that there is no columella and a very scanty endotheca. Still there is an endotheca; and the visceral cavity is not open from top to bottom, as in the *Turbinolidæ*. It is true that there is a facies common to the *Cœlosmiliæ*, and that they are a natural group; but in fact they would not differ from a well-known *Trochosmilia* with scanty endotheca, were there such a species. On studying the genus *Trochosmilia*, it will be noticed that many of its species have never been described with reference to their endotheca. Many were determined from one or two specimens, and sections of the majority have not been taken. Now *Trochosmilia sulcata*, Ed. & H., has very little endotheca; it is a species from the Gault, and the *Cœlosmiliæ* are all from the Upper Cretaceous, Eocene, and recent coral-faunæ. In placing *Cœlosmilia* as a subgenus, but included in *Trochosmilia*, it must be admitted that the classification becomes simpler and more natural. Since MM. Milne-Edwards and Jules Haime published their 'Hist. Nat. des Coralliaires' some new species of *Cœlosmilia* have been published or described. The known species were as follows:—

1. Cœlosmilia poculum, *Ed. & H.* Recent.
2. —— Faujasi, *Ed. & H.* White Chalk.
3. —— punctata, *Ed. & H.* White Chalk.
4. —— laxa, *Ed. & H.* Norwich Chalk.
5. —— Edwardsi, *D'Orb.* Sezanne.
6. Cœlosmilia Atlantica, *D'Orb.* Tuber Creek, New Jersey.
7. —— excavata, *Hag.*, sp.
8. —— radiata, *Quenstedt.* Natheim.

The new species are;—

10. Cœlosmilia elliptica, *Reuss.* Castelgomberto.
11. —— Javana, *Duncan*, MS. Java.
12. —— cornucopiæ, *Duncan.* Trimmingham chalk.
13. —— Wiltshiri, *Duncan.* Norwich Chalk.
14. Cœlosmilia Woodwardi, *Duncan.* White Chalk, England.
15. —— granulata, *Duncan.* White Chalk, England.
16. —— cylindrica, *Duncan.* White Chalk, England.

The species *cornucopiæ*, *Wiltshiri*, *Woodwardi*, *granulata*, and *cylindrica* are new to British palæontology, and are very characteristic of the Upper Chalk.

I have discovered three well-marked varieties of *C. laxa*.

An analysis of the species produces the following results:—

1. The species *Atlantica*, *punctata*, *Edwardsi*, *excavata*, and *radiata* either pertain to other species, or are really indeterminable.

2. The species whose septal arrangement shows more cycles than four, or some septa of the fifth cycle, are:—

Cœlosmilia poculum.
—— Faujasi.
—— Javana.
—— cornucopiæ.
Cœlosmilia Wiltshiri.
—— Woodwardi.
—— elliptica.

3. The species whose septal arrangement shows three cycles, or four cycles, or some septa of the fourth cycle, are:—

Cœlosmilia granulata.
—— cylindrica.
Cœlosmilia laxa.

4. The species with large bases and with more than four cycles are:—

Cœlosmilia poculum. Cœlosmilia elliptica.

5. The species with a large base and with more than three cycles of septa, but not more than four, is

Cœlosmilia cylindrica.

Having scanty endothecæ with wide bases:—

The costæ hardly prominent, replaced inferiorly by granules, 5 cycles, corallum straight	Trochosmilia	(C.) poculum, *Ed. & H.*
The costæ cristiform, superiorly with intermediate costæ, corallum curved	——	(C.) elliptica, *Reuss*, sp.
The costæ very distinct, flat, wide, intercostal spaces linear, 4 cycles, corallum cylindrical...	——	(C.) cylindrica, *Duncan.*

With pedicel, or a small trace of former attachment, 5 cycles:—

The costæ throughout indistinct, plane, and unequal.	Trochosmilia	(C.) Faujasi, *Ed. & H.*
The costæ alternately large and small, subcristiform above, crossed by ornamentation	——	(C.) Javana, *Duncan.*
The costæ subcristiform throughout, subequal above...	——	(C.) cornucopiæ ,,
The costæ very distant, distinct and subcristiform, smaller, much ornamented	——	(C.) Wiltshiri, ,,
The costæ long, the principal cristiform, many smaller between them, corallum long and cornute...	——	(C.) Woodwardi, ,,

Four cycles or part of the fourth:—

The costæ well marked, distant, very granular, intercostal spaces very granular and strongly marked, corallum curved	——	(C.) granulata ,,
The costæ distant, distinct, and cross-marked in intercostal spaces	——	(C.) laxa, *Ed. & H.*

Trochosmilia (Cœlosmilia) laxa, Ed. & H.

In examining good specimens of this species I found the fourth cycle of septa to be present. Its laminæ are small, but decidedly visible; consequently the calice, as drawn by MM. Milne-Edwards and Jules Haime, 'Monog. Brit. Foss. Corals,' pt. 1. tab. viii. fig. 4 *c*, is incorrect. The following description will apply to the three varieties of the species.

Variety 1. The corallum is conico-cylindrical and straight. The costæ are intensely granular inferiorly, and two large costæ are separated by three smaller. Near the calice the larger costæ have a wavy cristiform ridge upon them, the intermediate costæ being very granular, with chevron patterns, or they may be moniliform. At the calicular margin the costæ are nearly flat and granular. The fourth cycle of septa is distinct.

Variety 2. Inferiorly, in structure as *variety* 1. Superiorly the principal costæ are very cristiform, and well marked with a secondary ridge. The chevron pattern of the intermediate costæ are very distinct.

Variety 3. Costæ inferiorly wavy and sparely granular. Superiorly the costæ are subcristiform and plain, the continuity of the crests being defective. The intermediate are broken and moniliform, and here and there chevroned.

Trochosmilia (*Cœlosmilia*) *cornucopiæ*, Duncan.

The corallum is strongly curved in the plane of the smaller axis, and it is compressed superiorly, and is finely pedunculate. The growth-rings and swellings are moderately developed. The costæ are subequal above and cristate, and unequal inferiorly. The septa are numerous and very unequal. There are five cycles of septa, and six systems. The primary septa are very exsert, and the secondary ones less so. The septa of the fifth cycle are very small. The calice is elliptical and the fossa very deep, the larger septa joining those opposite at its bottom. There are traces of epitheca.

Height 1 inch. Breadth of calice $\frac{5}{6}$ inch. Length of calice 1 inch. Depth of fossa $\frac{5}{6}$ inch.

Locality. Trimmingham, Upper Chalk.

In the collection of the Rev. T. Wiltshire, F.G.S. &c.

Trochosmilia (*Cœlosmilia*) *Wiltshiri*, Duncan.

The corallum is tall, finely pedicellate, and is not compressed. The growth-rings are distinct. The costæ are very distinct and unequal, and they reach from base to calice. The smaller intermediate costæ are ornamented with chevrons and horizontal lines. The larger costæ have a secondary crest upon their free surface. The septa are unequal, slender, and not crowded. The calice is circular. There are five cycles of septa, but the fifth is incomplete in some systems. The primary septa are large, slightly exsert, and extend far inwards. The calicular margin is very thin, and the fossa is deep.

Height $1\frac{2}{3}$ inch. Diameter of calice $\frac{2}{3}$ inch.

Locality. Norwich, Upper Chalk.

In the collection of the Rev. T. Wiltshire, F.G.S. &c.

Trochosmilia (*Cœlosmilia*) *Woodwardi*, Duncan.

The corallum is tall, cornute, slightly pedicellate and narrow. The growth-markings are distinct. The costæ are distinct from base to calice. Two large subcristiform and very distinct costæ bound three intermediate small and more or less moniliform costæ. Sets of these costæ occur around the corallum. The septa are crowded, wavy, and unequal; many unite laterally, and the largest reach far into the axial space. The calice is circular, and the wall is very thin.

Height 2 inches. Breadth of calice $\frac{5}{6}$ inch.

Locality. Chalk of South of England.

In the British Museum, Dixon Collection.

Trochosmilia (*Cœlosmilia*) *granulata*, Duncan.

The corallum is tall and slightly curved; it has a long pedicel with a very distinct base. The corallum is slightly compressed, and bulges here and there. The costæ are well marked, distant, subequal, and intensely granular. The larger costæ are more distinct inferiorly and midway than close to the calicular margin; they are cristiform in some places, notched by chevron-shaped ornamentation in others, and occasionally sharply pointed or absent. The spaces between the larger costæ are wide, faintly convex, and are marked longitudinally by small costæ, and transversely by wavy or chevroned ornamentation. The whole external surface of the corallum is very granular. The calicular wall is very thin, and the calice is elliptical. There are three perfect cycles of septa, and some orders of the fourth cycle in some of the systems. The septa are wide apart, slightly exsert, unequal, and slender; they do not reach far inwards at once, but dip downwards with a gentle curve. In a section the inner margin of the lower septa is wavy. The endotheca is scanty.

Height $1\frac{2}{3}$ inch. Length of calice $\frac{5}{6}$ inch. Breadth $\frac{2}{3}$ inch.
Locality. Norwich, and Chalk of South of England.
In the British Museum, Dixon Collection.

Trochosmilia (*Cœlosmilia*) *cylindrica*, Duncan.
The corallum is tall, cylindrical, and very slightly bent. The calicular opening is smaller in diameter than the rest of the corallum. The costæ are nearly equal, broad, slightly crowded, and are separated by shallow, narrow and undulating intercostal grooves. The costæ are profusely ornamented with transverse ridges, straight, curved, or angular, and with large granules. The calicular edge is very thin, and the broad convex costæ are continuous with slender unequal septa. The primary are exsert, and the laminæ of the higher orders are very small. There is no columella, the larger septa uniting by a few short attachments from their inner margins. The endotheca is scanty.
Height several inches. Breadth of the calice $\frac{5}{6}$ inch.
Locality. Norwich, Upper Chalk.
In the collection of the Rev. T. Wiltshire, F.G.S. &c.

The subgenus *Cœlosmilia* is thus represented in the British chalk by one species formerly known, by three varieties of it, and by five new species:—

1. Trochosmilia (Cœlosmilia) laxa, *Ed. & H.*
   —— (——) ——, vars. 1, 2, 3, *Duncan.*
2. —— (——) cornucopiæ, *Duncan.*
3. —— (——) Wiltshiri, *Duncan.*
4. Trochosmilia (Cœlosmilia) Woodwardi, *Duncan.*
5. —— (——) granulata, *Duncan.*
6. —— (——) cylindrica, *Duncan.*

These *Trochosmiliæ*, with a slight amount of endotheca (and what there is of it is generally low down), are very characteristic of the Upper Chalk; and their presence suggests that the Upper Chalk of Norwich and Trimmingham is, from the evidence of its corals, as well as from the proofs already adduced from its Mollusca, on a higher horizon than the Upper Chalk (usually so called) in the south-eastern district. The coral evidence brings the Norfolk chalk closer in relation with the Faxoe, Rugen, and Ciply deposits†.

The affinity between *Trochosmilia* (*C.*) *cornucopiæ* and *Cœlosmilia excavata*, Hag., sp., a doubtful form, but well drawn by Quenstedt, is evident. It is from Rugen and Moen. *T. Wiltshiri* and the species *Faujasi*, from Ciply, are also closely allied.

The depth of the space between the calicular margin and the top of the upper dissepiment in these species indicates that the animal had great mesenteric, ovarian, perigastric, and water systems. They were probably very rapid growers. The wall is merged into the costal system, which is strengthened by a most unusual cross-bar and cristiform ornamentation; and this development, which is almost epithecal, is complementary to the defective endotheca.

Family ASTRÆIDÆ.

Division Trochosmilia.

Genus Parasmilia.

MM. Milne-Edwards and Jules Haime described five species of this genus from the Upper Chalk, viz.:—

1. Parasmilia centralis, *Mantell*, sp.
2. —— Mantelli, *Ed. & H.*
3. —— cylindrica, *Ed. & H.*
4. Parasmilia Fittoni, *Ed. & H.*
5. —— serpentina, *Ed. & H.*

† With regard to the depth at which *Oculinidæ* and simple corals can live, it has been discovered by Dr. Carpenter and Prof. Wyville Thompson that they exist at a depth of 530 fathoms.

P. cylindrica and *serpentina* are readily distinguished by their external shape; but, owing to the polymorphic character of *P. centralis*, it is by no means easy to separate it from *P. Mantelli* and *P. Fittoni*.

Parasmilia Mantelli, Ed. & H., was determined from one specimen alone, and it is clearly united to *P. centralis* by *P. Gravesana*, Ed. & Haime, of the White Chalk of Châlons-sur-Marne and Beauvais (Oise). This species I have found in England; and having had many specimens of *P. centralis* with costæ like those of *P. Mantelli* in some parts of the corallum, and normal costæ in others, I consider *P. Mantelli* a variety of *P. Gravesana*, and that this last species is a variety of *P. centralis*, a good subspecies.

Parasmilia Fittoni, Ed. & H., has a large columella and a definite structural distinction in its tertiary costæ from *P. centralis*.

The new forms I have noticed with the older are shown in the following list:—

1. Parasmilia centralis, *Mantell*, sp.
—— ——, var. Mantelli.
—— ——, subspecies Gravesana, *Ed. & H.*
2. —— Fittoni, *Ed. & H.*
3. Parasmilia cylindrica, *Ed. & H.*
4. —— serpentina, *Duncan.*
5. —— monilis, *Duncan.*
6. —— granulata, *Duncan.*

Parasmilia monilis, Duncan.

The corallum is long, much curved, and distorted. It is more or less cylindrical above and contracted here and there. Inferiorly it is pedunculate, the peduncle being small, curved, and long. The costæ are nearly equal on the peduncle; there they are rather subcristiform, a secondary crest being on the costæ; and in the intercostal spaces there is either a faint ridge or a moniliform series of granules. The calice is often smaller than the body, and the wall is very thin. The septa are small; and there are four cycles, the last cycle being rudimentary. The columella is small.

The height varies from $\frac{1}{4}$ inch to 2 inches, and the diameter from $\frac{1}{2}$ to $\frac{2}{3}$ inch.

Locality. Gravesend.

In the collection of the Rev. T. Wiltshire, F.G.S.

Parasmilia granulata, Duncan.

The corallum is tall, nearly straight, finely pedunculate, and cylindro-conical. The calice is very large, widely open, deep, and has a thin margin. The columella is well developed. The septa are barely exsert, reach but slightly inwards, but pass downwards at once. They are very unequal, alternately large and small, and there are four complete cycles and part of the fifth. The costæ are subequal near the calice, and the broadest are continuous with the smallest septa. On the body the costæ are subcristiform and in sets of four. On the pedicel they are very granular and very distinct.

Height $1\frac{1}{3}$ inch. Breadth of calice $\frac{1}{2}$ inch.

In the British Museum, Dixon Collection.

This species was included by Lonsdale in his genus *Monocarya*, and was termed *M. centralis*. *Parasmilia* has the priority as a genus; and the species is evidently not *P. centralis*. The position of the genus *Parasmilia* is somewhat like that of *Cœlosmilia*; but MM. Milne-Edwards and Jules Haime have created the genus *Cylicosmilia* for *Parasmiliæ* with abundant endotheca. Now in careful sections I have found that *P. centralis* and its varieties have endothecal dissepiments reaching close to the calicular fossa. The genus must therefore absorb *Cylicosmilia*; and *C. Altavilensis*, Defrance, sp., of the Eocene of Hauteville must become *Parasmilia Altavilensis*, Defrance, sp. Reuss has described an Eocene *Parasmilia* from Monte Grumi which is closely allied to the *centralis* series.

(Order ZOANTHARIA APOROSA.)

Family OCULINIDÆ.

Genus Diblasus, Lonsdale.

This genus was established by Lonsdale in Dixon's 'Geol. of Sussex,' 1850, and was described by the learned zoophytologist with all that critical acumen which characterizes him, pp. 248 to 254, pl. 18. figs. 14 to 28.

MM. Milne-Edwards and Jules Haime, whilst they acknowledge the genus to be "voisin des Synhelia" (Hist. Nat. des Corall. vol. ii. p. 115), do not give it a place in their classification. I have therefore carefully studied and drawn the specimens from the Dixon Collection in the British Museum, and have great pleasure in doing justice to Mr. Lonsdale, by inserting his genus with slight alterations to meet the present terminology.

Genus *Diblasus*, Lonsdale (amended).

The corallum is incrusting, very irregular in shape; the calices are wide apart and projecting; the intercalicular tissue is costulate. The septa are unequal. There are no pali. The columella is formed by the junction of the larger septa, and does not exist as a separate structure. Gemmation marginal and intercalicinal. The genus is evidently not closely allied to *Synhelia*; for it has no palular or true columellary structures. It approaches the genus *Astrohelia*, which is a transition genus bringing the *Oculinidæ* in relation with the *Astræinæ* through the *Cladangiæ* (Milne-Edwards and Jules Haime, 'Hist. Nat. des Corall.' vol. ii. p. 111).

Diblasus Grevensis, Lonsdale.

The corallum is very irregular in shape and size. The calices project, and are irregular in their projection and size. The costæ are granular, equal, subequal, and unequal in different parts of the same corallum. The septa are in three cycles, and are unequal and dentate; the primary reach those opposite, and form a rudimentary columella; they are crowded, and are granular laterally. Diameter of usual-sized calices $\frac{1}{6}$ inch.

Locality. Gravesend Chalk.

In the British Museum, Dixon Collection.

The condition in which the specimens of this species is found is very remarkable: the inside of nearly every calice has been worn away, so that the mural edges of the septa are all that remains of them; the perfect calices appear to have shrunk from the surrounding cœnenchyma; and in many places the costæ have been worn off.

Lower Chalk.

There are several specimens of corals from the Lower Chalk; but I have not been able to identify them, on account of their fragmentary condition. *Onchotrochus serpentinus* is a Lower-Chalk form.

Fossil Corals from the Upper Greensand.

The following authors have written on this subject:—W. H. Smith, 'Strata identified by Organic Fossils,' 1816. Godwin-Austen, Trans. Geol. Soc. 2nd Series, vol. vi. p. 452. Morris, 'Cat. of British Fossils,' p. 46 (1843). MM. Milne-Edwards and Jules Haime, *op. cit.*

The scanty Coral-fauna of this deposit was described by MM. Milne-Edwards and Jules Haime; and although some years have elapsed since the publication of the first part of the 'British Fossil Corals' (Pal. Soc.), and the beds have been well searched, very few additions can be made to the list of fossils.

The following is a list of the published species (1850).

1. Peplosmilia Austeni, *Ed. & H.*
2. Trochosmilia tuberosa, *Ed. & H.*
3. Parastræa stricta, *Ed. & H.*
4. Micrabacia coronula, *Goldfuss*, sp.

In their 'Hist. Nat. des Corall.' vol. ii., MM. Milne-Edwards and Jules Haime make some alterations in the synonyms of the genera, and add a species to the list. They do not give any further information respecting some doubtful species noticed by Messrs. Godwin-Austen and Prof. Morris.

Their amended list is as follows.

1. Peplosmilia Austeni, *Ed. & H.*
2. Smilotrochus tuberosus, *Ed. & H.*
3. —— Austeni, *Ed. & H.*
4. Favia striata, *Ed. & H.*
5. Micrabacia coronula, *Goldfuss*, sp.

Specimens belonging to the following species have been submitted to me.

1. Onchotrochus Carteri, *Duncan.*
2. Smilotrochus elongatus, *Duncan.*
3. —— angulatus, *Duncan.*
4. Cyathophora monticularia, *D'Orbigny.*
5. Favia minutissima, *Duncan.*
6. Thamnastræa superposita, *Michelin.*

Trochosmilia tuberosa, Ed. & H., was found to be without endotheca, and therefore to be of necessity included amongst the *Turbinolidæ*. The genus *Smilotrochus* was determined in order to receive the species.

Genus Smilotrochus, Ed. & H.

The corallum is simple, straight, cuneiform, free, and without trace of former adhesion. There is no columella, the wall is naked and costulate. There is no epitheca, and the simple costæ are distinct from the base to the calice.

This is the simplest form of Aporose Zoantharia; and its structures are confined to a wall, septa, and costæ. *Flabellum* has an epitheca in addition, and *Stylotrochus* of De Fromentel is a *Smilotrochus* with a styliform columella, the septa uniting also by their thickened internal margins. *Onchotrochus*, nobis, has a pellicular epitheca, no columella; but, like *Stylotrochus*, the septa are united internally.

1. *Smilotrochus tuberosus*, Ed. & H.
   Trochosmilia tuberosa, *Ed. & H.*
   Turbinolia compressa? *Morris.*

This species with five cycles of septa was described in the 'Monog. of the Brit. Foss. Corals,' Upper Greensand, Milne-Edward and Jules Haime (Pal. Soc.).

2. *Smilotrochus Austeni*, Ed. & H.

This species is described in the 'Hist. Nat. des Corall.' vol. ii. p. 71.

The corallum is regularly cuneiform, very compressed below, and slightly elongate. The calice is elliptical, the summit of the larger axis rounded; forty-eight costæ, subequal, straight, fine, and granular.

Height of the corallum about $\frac{1}{3}$ inch.

Locality. Farringdon.

MM. Milne-Edwards and Jules Haime do not mention where the specimen is.

3. *Smilotrochus elongatus*, Duncan.

The corallum is tall, straight, and nearly cylindrical. The columellary space is large. The septa are fine and unequal, especially in length; there are four cycles of septa.

Height about an inch.

Locality. Upper Greensand of Cambridgeshire.

In the collection of James Carter, Esq.

4. *Smilotrochus angulatus*, Duncan.

The corallum is conical, hexagonal, slightly curved at its very fine inferior extremity. It is broad superiorly, and has six prominent angles, and is compressed slightly. The septa are fine, unequal, and each plane between the angles has a system of four cycles. The columellary space is large.

Height $\frac{3}{4}$ inch. Breadth $\frac{1}{2}$ inch.

Locality. Upper Greensand of Cambridge.

In the collection of James Carter, Esq.

Genus Onchotrochus.

Numerous specimens of a species of this genus are in the possession of James Carter, Esq. and the Rev. T. Wiltshire. The species has great resemblance to the lower part of *Onchotrochus serpentinus*, nobis. A careful examination of sections and calices proves that there is no columella, that the inner ends of the septa produce a false one, and that the styloid appearance is due to fossilization.

Onchotrochus Carteri, Duncan.

In the young corallum there is a flat and round expansion at the base, by which it was attached to foreign substances; but this is lost as growth proceeds. The corallum is either straight or slightly curved, is tall, very slender, conico-cylindrical, clavate, and enlarged here and there. Unworn specimens are more or less angular in transverse outline. The costæ are angular projections, extend from base to calice, are subequal, wide apart, and are connected and covered with a fine pellicular epitheca, which readily disappears. Growth-markings very common. The calice is circular and shallow. The septa are short at the wall, and wedge-shaped; they are rounded inferiorly, and do not extend far inwards. There are twelve septa, and they are subequal. The septa in sections often appear equal, and their inner ends are joined, and the axial space is filled up by a deposit of coral-structure. But the reverse is the case occasionally, and the irregularity of the septa may be well seen. The septa are continuous with the costæ.

Height $\frac{1}{3}$–$\frac{2}{3}$–1 inch. Diameter of calice $\frac{1}{12}$ inch.

Locality. Cambridge Greensand.

In the collection of James Carter, Esq. and Rev. T. Wiltshire.

The discovery of better specimens may perhaps lead M. de Fromentel to consider his *Stylotrochus*, which so resembles this form, to be of the same genus.

Genus Cyathophora, *Michelin.*

This genus has the usual characters of compound Astræinæ; but the dissepiments act as tabulæ, and shut in the calice below, just as in some of the Liassic *Isastrææ*. There is no columella*. Curved dissepiments are not noticed; and the family of the genus must remain unsettled, for the minute structure is clearly tabulate. The genus flourished in the Lower and Middle Oolites; and the only Cretaceous species is that under consideration, and which has been described by D'Orbigny from the Craie Tuffen, Les Martigues —*Cyathophora monticularia*, D'Orb., sp.

The septa are rather thick. There are three cycles, but the third is often deficient in one or two systems.

Locality. Haldon.

In the collection of the Geological Society.

* See remarks on Liassic *Isastrææ*.

Genus Favia.

This genus has absorbed the *Parastrææ*, so that *P. stricta* has become *Favia stricta.*

Favia minutissima, Duncan.

The corallum is incrusting, gibbous, and small. The calices are very small, close, and with very scanty intercorallite tissue. There are twelve septa, and the costæ are continuous.

Diameter of the calices under $\frac{1}{12}$ inch.

Locality. Haldon.

In the collection of the Geological Society.

This is the smallest of the *Faviæ.*

Genus Thamnastræa.

Thamnastræa superposita, Michelin, sp.

MM. Milne-Edwards and Jules Haime thus notice this species (Hist. Nat. des Corall. vol. ii. p. 559):—

"M. Michelin's specimen is very young. It is encircled by a strongly folded epitheca, which is formed of two layers. No columella is distinguishable. The septa are tolerably strong and unequal. There are three cycles, with the rudiments of a fourth in one or two systems."

The superposition of the calices is remarkable; and I cannot but place a coral found in the Irish Upper Greensand by Ralph Tate, Esq., F.G.S., in this species.

Locality. Ireland, Upper Greensand.

In the collection of R. Tate, Esq., F.G.S, &c.

Fossil Corals from the Red Chalk of Hunstanton.

The Red Chalk of Hunstanton contains several forms of Madreporaria. The small fauna has this peculiarity; its species belong to the group of Fungidæ without exception. The specimens are small, usually much worn at the calicular end, and are readily distinguished by their mammiliform appearance and white colour.

There are no compound Fungidæ in the Red Chalk, but such small, simple forms as would now characterize the presence of physical conditions unfavourable for coral-life. The recent simple Fungidæ are found at all depths; vast numbers of them are to be collected in the Gosau Lower Chalk; a few existed in the Upper Greensand and the Neocomian, and are found in the existing coral-fauna; none are found in the West-Indian seas, whilst the Red Sea, Pacific, and Indian oceans abound with them. It is probable that peculiar conditions are necessary for their development.

List of species in the Red Chalk of Hunstanton.

1. Micrabacia coronula, *Goldfuss*, sp.
   —— ——, var. major.
2. Cyclolites polymorpha, *Goldfuss*, sp.
3. Podoseris mammilliformis, *Duncan.*
4. —— elongata, *Duncan.*

Family FUNGIDÆ.

Subfamily Fungiæ.

Genus Micrabacia.

There are specimens of a small form of *Micrabacia coronula*, Goldfuss, sp., and of a large variety, in the red rock; the species is well known in the Upper Greensand of England, and in the Chalk of Essex. There is another

species, which is hardly distinguishable from *M. coronula*, in the Neocomian of Caussols (var.).

The variety of the species in the red rock rather resembles the Neocomian species in its diameter and flatness. The genus had a very short vertical range, and was represented in later times by the *Stephanophylliæ*.

Subfamily Lophoserinæ.

Genus Cyclolites.

This genus almost characterized the geological horizon of the Craie-Tuffeau of Gosau, the Ile d'Aix, les Martigues, Vaucluse, Corbières, Uchaux, &c. A few species are found in the White Chalk, in the Eocene, and Miocene. There are some doubtful Neocomian species; and the genus is extinct.

Cyclolites polymorpha, Goldfuss, sp.

The corallum is very irregular in shape, generally subelliptical, and not very tall. The highest point of the calice is subcentral, and the central fossula is very variable in its place. The septa are very numerous, thin, close, flexuous, crenulate, and larger in front.

The solitary specimen of this form is small, but the fossula and septa are tolerably distinct.

Genus Podoseris, *Duncan*.

The corallum has a large concave base, by which it is attached to foreign bodies. The epitheca commences at the basal margin, and is stout and reaches the calicular margin. The height of the corallum varies. The calice is generally smaller than the base, and is convex. The septa are numerous and unequal, the largest reaching the rudimentary columella. The central fossula is circular and small. The costæ are seen when the epitheca is worn; they are distinct, connected by synapticulæ, and are straight.

The genus has been created to admit *Micrabaciæ* with adherent bases and more or less of a peduncle.

Podoseris mammilliformis, Duncan.

The corallum is short, straight, and broad. The base is concave, and is either larger than the calice, or there is a constriction immediately above it, and it is slightly smaller than the calice. The calice is round, convex, depressed in the centre, and is bounded inferiorly by the epitheca. The laminæ are stout, unequal, curved superiorly, and often join. There are five cycles in six systems, the last cycle being very rudimentary. The synapticulæ are numerous. The costæ are straight and subequal, and are smaller than the septa. The ornamentation of the septal and costal apparatus varies; and there may be an almost moniliform series of enlargements on the septa, or they may be plain. The columella is formed principally by the ends of the longest septa. The height of the corallum appears to be determined by the growth of the body between the base and the calice.

Height of the corallum $\frac{1}{4}$ inch. Breadth of calicular margin $\frac{1}{3}$ inch.

Height $\frac{1}{6}$ inch. Breadth of calicular margin $\frac{1}{4}$ inch.

Height $\frac{1}{2}$ inch. Breadth of calicular margin $\frac{11}{30}$ inch.

Monstrosities are often found amongst specimens of this species.

Podoseris elongata, Duncan.

The corallum is tall, a broad circular and slightly concave base, a long conico-cylindrical stem, and a small calice much narrower than the base. The epitheca is in bands. The costæ are alternately large and very small, somewhat distant, wavy, and united by synapticulæ, many of which are oblique.

The septa frequently unite by their axial ends to each other, the short to the long. There appear to be five cycles of septa. The base of the corallum has a cellular tissue, probably from the fossilization of some body to which it was adherent.

Height $\frac{5}{6}$ inch. Breadth of base $\frac{1}{2}$ inch. Breadth of calice $\frac{1}{4}$ inch.

The shape of this species is most unusual.

These corals are all in the collection of the Rev. T. Wiltshire, F.G.S.

It is evident that the coral evidence places the Red rock in the Upper-Greensand horizon.

Corals from the Lias.

When MM. Milne-Edwards and Jules Haime wrote their 'Monograph of the British Fossil Corals' (Pal. Soc.), only one good species was known as Liassic. There was a great palæontological break between the coral-faunæ of the Inferior Oolite and of the Mountain-limestone. The distinction between the Palæozoic and Jurassic coral-faunæ was so great that any student of the Mesozoic Zoantharia appeared to enter another Madreporarian world when the Carboniferous forms were presented to his notice. On leaving the study of the *Montlivaltiæ, Thecosmiliæ, Isastrææ,* and other familiar Secondary genera, and entering upon the investigation of such genera as *Cyathophyllum, Lithostrotion, Lonsdalia,* and *Amplexus,* a new classificatory philosophy had to be comprehended, and it required much experience in the habit of determining species before the foreshadowing of the Secondary forms could be appreciated in the Palæozoic. The break was produced by the very uncoralliferous nature of the Permian strata, the absence of any corals from the Trias in this country, and the solitary species from the Lias.

Of late years the distinction between the Palæozoic and Oolitic coral-faunæ of continental Europe has been lessened by the careful study by Laube and Reuss of the Triassic coralliferous limestones, and by De Fromentel, Ferry, Terquem, Piette, and Stoppani of the corals of the *Avicula-contorta* zone, and of the strata sometimes called Infralias, in which *Ammonites planorbis* and *A. angulatus* are found. The Palæozoic genera said to be found in the Muschelkalk and in the St.-Cassian beds were proved by Laube to be Secondary, and the small coral-fauna of the Lias below the zone of *Ammonites Bucklandi* (*bisulcatus*) was determined to be decidedly Jurassic in its affinities. The break was thus narrowed; but it was nevertheless very great; for the absence of any satisfactory assemblage of forms in the Permian formation and in the Muschelkalk rendered the aspect of the Carboniferous specific group very foreign to the student of the lowest Mesozoic corals.

Some recent discoveries of Permian corals in North America do not help to diminish this break.

The practical geologist will readily appreciate the vast physical changes which intervened between the Mountain-limestone and the *Avicula-contorta* beds in this country. The depth of the Permian magnesian and sandy deposits and of the Bunter on the Continent and its limestone (Muschelkalk), and that of the Keuper and its St.-Cassian and Kössen strata, will strike all who know that corals are the rarest of specimens in this pile of deposits; so that when the admirable condition of preservation of the Carboniferous corals and of those from the Lower Lias is considered, the imperfection of the record appears to be immense.

The earliest evidences of the existence of Secondary corals in this country are the casts of simple forms, probably of *Montlivaltiæ* from the *Avicula-contorta* beds, and the casts and corallites of *Montlivaltiæ* and the *Thecosmiliæ* from the

true White Lias. As the balance of the Palæontological evidence is in favour of these beds being younger than the Trias, they must be considered the feebly coralliferous strata of the Rhætic strata, or of the Infralias, or Lower Lias, according to the taste of the student of dogmatic systematic geology. The deposits containing *Avicula contorta* in England, Wales, and Ireland are not of that physical and mineralogical character which attends coralliferous sediments; and the assemblage of other organisms is not that which usually accompanies coral life.

A cast of a *Montlivaltia* was discovered in the *Avicula-contorta* zone, by Charles Moore, F.G.S.; and it is therefore an interesting fossil; for, except the few Permian specimens, there are no corals known in Great Britain between this cast and the Madreporaria of the Carboniferous.

Throughout Europe the strata containing *Avicula contorta* are generally uncoralliferous; but the great deposits at Azzarola have an old coral-bank. These were the coral-reef areas of the period, just as the Gosau and Martigues were the coral-reef areas of the Lower Chalk, and as the Dax and Caribbean strata were the coral-reef areas of the Miocene.

The White Lias of Great Britain and Ireland is a local deposit which is intercalated between the beds containing *Avicula contorta* and those constituting the zone of *Ammonites planorbis* (or its equivalent Ammonite, such as *A. Burgundiæ*). It is absent on the continent, the *Ammonites planorbis* (or its equivalent deposit) succeeding the beds with *Avicula contorta.* The White Lias is very uncoralliferous; and I have never seen a perfect specimen of a Madreporarian from it. The White Lias of Watchet contains imperfect *Montlivaltiæ* and stunted conico-cylindrical *Thecosmiliæ.* A cast of a Thecosmilian from Sparksfield resembles that of a species found in the deposits above the White Lias in the zone of *Ammonites-planorbis* and *A. angulatus.*

A large *Montlivaltia* from the White Lias near Leamington has an elliptical calice; but it is not possible to give it a specific determination. A cast of a multiseptate discoidal *Montlivaltia* is found at Punt Hill, Warwickshire; it resembles that of *Montlivaltia Haimei*, Chapuis et Dewalque. Corals of this type are common in the *Ammonites-planorbis* beds of the east of France and Luxembourg, but they do not appear to have existed in England until the zone of *Ammonites angulatus.* This species, having a range from the east of France to the west of England and Ireland, is very variable in its form and in some structural details.

It is evident from an examination of the Mollusca of the White Lias, that it was a deposit not likely to have corals located in it. The stunted *Thecosmiliæ* and discoid *Montlivaltiæ* have no congeners now existing; but many genera of simple corals of tubular form are frequenters of the sea-bottom from 100 fathoms to the lowest spring-tide range.

The coral-fauna of this deposit is unimportant, and even that of the next series of beds, those containing *Ammonites planorbis*, is small; but when the strata in which *Ammonites angulatus* existed was examined, a large and very varied assemblage of species, indicating old coral-reefs, as well as deep-water conditions, was proved to exist. In South Wales a reef hung on to the Mountain-limestone coast; and in the North of Ireland, as well as in the Lincolnshire area, sublittoral and deep-water forms flourished. Changes occurred in the physical geography of these areas, and an arenaceous series of deposits containing *Gryphæa incurva* and *Ammonites Bucklandi* succeeded the Welsh deposits just mentioned, and the deeper sea-beds of the east and west. The alteration in the sea-depth due to the lowering of these areas produced not only an alteration in the mineralogy of the strata, but great

modifications in the faunæ, especially as regards the corals. The arenaceous limestones situated upon the coralliferous dolomitic limestones of the old Welsh reef contain a feeble coral assemblage, and present no evidence of the existence of coral reefs. A great number of Mollusca are found in the deposits; some existed during the deposition of both, and others were limited in their range to one or the other; but the bathymetrical changes gave the corals no chance, and doubtless the reef species died out, their ova finding no resting place on that particular area.

The zones which succeeded *Ammonites Bucklandi* appear to have been unfavourable to certain forms of corals, especially to those which collect together in vast tracts, forming varieties of reefs. The modern representatives of the species found in the Liassic strata above the zone of *Ammonites angulatus* indicate deep water (30 to 100 fathoms). Where the reefs of the period were is certainly not determinable.

The corals of the Middle and Upper Lias are very rare.

The corals contained in the Liassic strata of Britain, France, Germany, and Italy have a very decided community of facies; at the same time it is evident that some portions of the Liassic coral-fauna resemble Triassic types, and that another portion is allied to the Oolitic.

This was to have been expected; for it is evident that the stunted *Thecosmiliæ* and the *Astrocœniæ* of the zone of *Ammonites angulatus* are the descendants of the equally stunted *Thecosmiliæ* and *Astrocœniæ* of the Triassic age. Moreover the descendants of the *Isastrææ* and of the larger *Montlivaltiæ* of the Lower and Middle Lias luxuriated in the Oolitic seas. The bulk, however, of the Liassic coral-fauna is characteristic of and special to the formation, and, as is the case in the other great series of strata, certain assemblages of species appear to characterize certain definite horizons. Yet not unexceptionably; for some species range into higher zones in certain areas, whilst others, which are confined to a definite horizon in one area, are found below and above the equivalents of the horizon in a distant locality. Thus a species which is only found in a particular bed, and is associated with a particular molluscan fauna in one locality, may be found associated with a molluscan fauna antecedent or subsequent in its recognized succession in another place.

The persistence of a species in a succession of deposits and its consecutive association with different groups of contemporaries and competitors is constantly observed in the Lias.

The groups of Madreporaria have a general relation to certain zones of life and to certain strata, besides very definite relations to others. It is not probable that corals and Ammonites had any close biological relations, but only those of a general nature; but corals were certainly *en rapport* with certain molluscan genera, especially with lithodomous groups; so that when corals of the Lias are said to belong to such and such a zone of *Ammonites*, it is to serve the purpose of the artificial but very necessary classificatory system of geology. If the Madreporaria are associated with certain Ammonite zones, it must be understood that it is only an approximative classification, and that the Ammonites and the Madreporaria may range higher than their supposed restricted zone, or not even be represented in certain portions of its area.

There are a few Triassic species in the Liassic coral-fauna, and the branching corals of the Sutton stone have generally a Triassic facies. The majority of the corals of the Lower Liassic strata are peculiarized by the imperfection of the septal arrangement, and by their epithecate wall. It may, in fact, be asserted that the so-called "rugose" characteristics of the greater part of the

Palæozoic coral-fauna had hardly left their hold upon Madreporarian life at the time when the Lower Liassic strata were deposited. No Palæozoic genus is represented in the Lias. The facies of the Lower Liassic Coral-fauna is produced by the multitude of branching *Thecosmiliæ*, stunted *Montlivaltiæ*, and small-caliced *Astrocœniæ*.

It is remarkable that neither Tabulate nor Perforate genera have been found in the Lias. The Tabulata must have been in existence during the Lias, for they are so fully represented in Palæozoic as well as in Cainozoic reefs.

Corals from the Zone of Ammonites planorbis.

There are some small *Thecosmiliæ* in the so-called Guinea beds at Binton and Wilmcote, which are doubtless the descendants of the *Thecosmiliæ* of the White Lias. One species passes up into the zone of *Ammonites angulatus* (*T. Terquemi*, Dunc.).

A very remarkable species of *Isastræa* is found in No. 3 bed of the Street section, associated with *Septastræa Haimei*, Wright.

This *Isastræa*, found so low in the secondary rocks, is especially interesting, on account of its possessing Latimæandræan characters, as well as true calicular gemmation close to the margin of the non-Latimæandræan calices.

Were certain portions of the corallum separated from others, two distinct genera would be made from them, according to the established rules of classification. The long serial calices without calicular buds are clearly *Latimæandræan*, and they grow in length by the gradual production of small septa amongst the others without a cyclical arrangement. In the non-serial calices the cyclical arrangement of the septa is not by any means perfect; and these calices differ from the non-serial calices of the *Latimæandræ* of the Inferior Oolite by their calicular gemmation.

Modern research into the relation between the hard and soft parts of recent corals has proved that the tentacular and oral structures of serial calices differ greatly from those which increase by a more or less cyclical arrangement of the septa. Moreover, the Isastræan under consideration is rather an abnormal form, from the size of the septal dentations, and the great development of the endothecal dissepiments. These last close in the bottom of the calices, stretching across the fossa after the manner of tabulæ.

The earliest known *Isastrææ* are from the Triassic beds, and *I. Haueri*, Laube, from St. Cassian, is certainly like the species now under examination—Latimæandræan in some respects. These species are synthetic, and point out the origin of the *Latimæandrææ*, which in later times became prominent members of the Jurassic coral-faunæ.

It must be remembered that St.-Cassian species of *Thecosmilia* and other genera have been found in the beds higher in the geological scale than the No. 3 bed (Street section), and also that *Isastrææ*, perfect in their generic attributes, have been described from the St.-Cassian limestone. I have named the new form *Isastræa latimæandroidea*.

Septastræa Haimei, Wright, sp., is found with the last species. It has fissiparous calices, no definite cyclical arrangement of its septa, and a strongly developed endotheca. Its alliance to *Septastræa excavata*, De From., is evident; but this last species has a definite hexameral arrangement of its cycles, as well as frequent fissiparity.

Fissiparity is produced by two large septa stretching across the calicular fossa, joining and then developing small septa from their sides. The large septa form the walls which separate the newly formed calices.

This is the earliest species of the genus which has been found in this country; but *Septastræa Fromenteli*, Terquem et Piette, which belongs to the zone of *A. planorbis* of the west, has been found in the zone of *A. angulatus* in the east of England. It may have flourished in the zone of *A. planorbis* in the west, and evidently existed contemporaneously with *Septastræa Haimei*. These are the earliest forms of the genus, which has many Isastræan characters, which has its corallite walls rather imperfectly united, and which is reproduced by ova and by fissiparity. It is evidently related to a genus of St.-Cassian corals which, although not found in the zone of *Ammonites planorbis* in this country, is represented by two species (one a St.-Cassian type) in the zone of *Ammonites angulatus*, in Glamorganshire. The genus is *Elysastræa*, Laube, which will be noticed presently.

Septastrææ are not found in Great Britain later than the Lias; but species occur in the French Oolites and in the Miocene. The genus is extinct.

It was always an assemblage of variable forms, and the irregular septal arrangement of the species was the rule. This will be observed from the study of the following Table.

		Regular septal arrangement.	Variable species.	Irregular septal arrangement.
Earliest	Septastræa Haimei	..	1	1
	—— De Fromenteli	...	1	1
A. angulatus	—— De Fromenteli	...	1	1
	—— excavata	1	...	...
A. Bucklandi	—— Eveshami	...	1	1
Oolitic	—— explanata	...	...	1
	—— dispar	...	...	1
Miocene	—— Forbesi	1	...	...

There are thus three genera of corals represented in the British zone of *Ammonites planorbis*:—

Thecosmilia Terquemi, *Duncan*.
Isastræa latimæandroidea, *Duncan*.
Septastræa Haimei, *Wright*, sp.

And by inference those genera were in existence during the deposition of the sediments of the zone which lived in St.-Cassian times, and in the age of the zone of *Ammonites angulatus*—such genera, for instance, as *Montlivaltia*, *Elysastræa*, *Astrocœnia*, *Rhabdophyllia*.

The zone of *Ammonites planorbis* is very distinctly developed in France and in Luxembourg, and it succeeds without any White Lias intervening upon the beds with *Avicula contorta*. In England the zone is but feebly developed, and the upper part of the White Lias cannot be separated from it. The separation of the zones of *Ammonites planorbis* (or its equivalent) and *A. angulatus* is satisfactorily determined on the continent, but it is not to be arbitrarily asserted for Great Britain; and in both cases large percentages of species are common to the upper and lower zone.

Triassic fish pass upwards into the zone of *Ammonites angulatus* in the French area, and Triassic Madreporaria are found in the corresponding zone in Glamorganshire. *Avicula contorta* and an Astrocœnian are common to the Azzarola beds, the *Avicula-contorta* zone of Great Britain, and the zone of *A. angulatus*. The French zones of the Lower Lias contain Azzarolan species. It must be conceded that the White Lias was deposited during the age of *A. planorbis* or *A. Burgundiæ* of the French area, the deposits being contemporaneous in a general sense—that the Azzarola deposit of Lombardy

was developed whilst the sediments containing *Avicula contorta*, the fossils of the White Lias, and those of part of the zone of *Ammonites planorbis* were being formed in the north-west of Europe—that the fauna of the *A. planorbis* zone was extended westwards, and became more decidedly associated with that of the zone of *A. angulatus*—that the St.-Cassian fauna was represented more or less in the Azzarola deposits—that the European area was not subject to violent disturbances between the deposition of the Azzarola beds containing *Avicula contorta*, and the commencement of the age of *Gryphæa incurva*—that simple bathymetrical changes produced first local, and subsequently general modifications of the faunæ—that faunæ which appear to have been consecutive were really synchronous, and that the lifetime of the St.-Cassian, Azzarola, *Avicula-contorta*, and Lower-Lias faunæ was embraced in a less extensive period than has usually been admitted. It is of the greatest importance to the palæontologist that every objection to the arbitrary classification of systematists in geology should be fully stated; and it is very evident that the physical breaks in the Upper Trias, Rhætic, and Lower Liassic strata are not accompanied by such decided palæontological changes as might be believed to have taken place.

Corals from the Zone of Ammonites angulatus, *Schl.*

There are some highly fossiliferous beds in South Wales, the West of England, the county of Lincoln, and in the North of Ireland which have the homotaxis of the typical strata of the continental zone of *Ammonites angulatus*, viz. the Calcaire de Valogne, the Foie de Veau in the Côte d'Or, and the Grès Calcareux in the Duchy of Luxembourg. The strata whence the ablest French palæontologists of the present day derived the magnificent Lower-Liassic (Infraliassic of some) molluscan fauna are the evident equivalents biologically, and perhaps chronologically of the Sutton stone, the conglomeratic deposits at Brocastle, the coralliferous bed at Cowbridge (all being in Glamorganshire, and known so thoroughly, thanks to Charles Moore), the beds above the White Lias at Marton in Lincolnshire, and some deposits at Waterloo, Larne, in the North of Ireland.

The British and continental deposits contain large numbers of molluscan species in common, and not a few Madreporaria; but the British strata were soon proved to be very coralliferous, especially in the west.

The following is a list of the species of corals from the continental zone of *Ammonites angulatus*.

1. Montlivaltia Sinemuriensis, *D'Orb.*
2. —— dentata, *De From. et Ferry.*
3. —— Martini, *De From.*
4. —— Rhodana, *De From. et Ferry.*
5. —— discoidea, *Terq. et Piette.*
6. —— Haimei, *Chap. et Dew.*
7. —— Guettardi, *Chap. et Dew.*
8. —— polymorpha, *Terq. et Piette.*
9. —— denticulata, *De From. et Ferry.*
10. Thecosmilia Martini, *De From.*
11. Thecosmilia Michelini, *Terq. et Piette.*
12. —— coronata, *Terq. et Piette.*
13. Septastræa Fromenteli, *Terq. et Piette.*
14. —— excavata, *De From.*
15. Isastræa Condeaua, *Chap. et Dew.*
16. —— Sinemuriensis, *De From.*
17. Stylastræa Sinemuriensis, *De From.*
18. —— Martini, *De From.*
19. Astrocœnia Sinemuriensis, *D'Orb.*
20. —— clavellata, *Terq. et Piette.*

Probably some of the species of *Montlivaltia* will have to be absorbed by others; but this list, when added to the Table of British Corals from the zone of *Ammonites angulatus*, proves that, instead of the Lias being an uncoralliferous series, it was quite the contrary. The great development of coral life in the Azzarola series, the scanty remains of it in the Western and North-western European *Avicula-contorta* zones, and in the White Lias and in the zone of *Ammonites planorbis*, and the luxuriance of the species in the zone of

Ammonites angulatus in the westernmost Lower Lias are most significant facts; and the significance is not diminished when the paucity of the species of the zone of *Ammonites Bucklandi*, and their distinctness from those of *Ammonites angulatus*, is considered.

List of British Species from the zone of Ammonites angulatus.

1. Oppelismilia gemmans, *Duncan.* Ireland.
2. Montlivaltia Walliæ, *Duncan.* South Wales.
3. —— Murchisoniæ, *Duncan.* South Wales.
4. —— Ruperti, *Duncan.* England.
5. —— parasitica, *Duncan.* South Wales.
6. —— simplex, *Duncan.* South Wales.
7. —— brevis, *Duncan.* South Wales.
8. —— pedunculata, *Duncan.* South Wales.
b. 9. —— polymorpha, *Terq. et Piette.*
b. 10. —— Haimei, *Ch. et Dew.* England and Ireland.
11. —— Hibernica, *Duncan.* Ireland.
12. —— papillata, *Duncan.* England.
c. 13. —— Guettardi, *Blainville.* England.
14. Thecosmilia Suttonensis, *Duncan.* South Wales.
15. —— mirabilis, *Duncan.* South Wales.
16. —— serialis, *Duncan.* South Wales.
17. —— irregularis, *Duncan.* South Wales.
18. —— Terquemi, *Duncan.* South Wales.
19. —— affinis, *Duncan.* South Wales.
20. —— dentata, *Duncan.* South Wales.
21. —— plana, *Duncan.* South Wales.
22. —— Brodiei, *Duncan.* South Wales.
b. 23. —— Martini, *E. de From.* England.
b. 24. —— Michelini, *Terq. et Piette.* England.
a. 25. Rhabdophyllia rugosa, *Laube.* South Wales.
a. 26. Rhabdophyllia recondita, *Laube.* South Wales.
b. 27. —— Astrocœnia Sinemuriensis, *D'Orb.* South Wales.
28. —— gibbosa, *Duncan.* South Wales.
29. —— plana, *Duncan.* South Wales.
30. —— insignis, *Duncan.* South Wales.
31. —— reptans, *Duncan.* South Wales.
32. —— parasitica, *Duncan.* S. Wales.
33. —— pedunculata, *Duncan.* South Wales.
34. —— costata, *Duncan.* South Wales.
35. —— favoidea, *Duncan.* South Wales.
36. —— superba, *Duncan.* South Wales.
37. —— dendroidea, *Duncan.* South Wales.
38. —— minuta, *Duncan.* South Wales.
39. Cyathocœnia dendroidea, *Duncan.* South Wales.
40. —— incrustans, *Duncan.* South Wales.
41. —— costata, *Duncan.* South Wales.
a. 42. Elysastræa Fischeri, *Laube.* South Wales.
43. —— Moorei, *Duncan.* South Wales.
b. 44. Septastræa excavata, *E. de From.* South Wales.
c. 45. —— Fromenteli, *Terquem.* South Wales.
46. Latimæandra denticulata, *Duncan.* South Wales.
b. 47. Isastræa Sinemuriensis, *E. de From.* South Wales.
48. —— globosa, *Duncan.* South Wales.
49. —— Murchisoni, *Wright.* Skye.
50. —— Tomesii, *Duncan.* Worcestershire.

This large Coral-fauna is made up of—

Series 1. Species ranging from the St.-Cassian beds	3
„ 2. Species ranging from continental zones of *Ammonites angulatus*	7
„ 3. Species from the Azzarola deposits	1
„ 4. Species from the continental zone of *Ammonites planorbis*	2
„ 5. Species peculiar to the British deposits...........	37
Total..............	50

The first series comprehends—

Thecosmilia rugosa, *Laube*,
Rhabdophyllia recondita, *Laube*,
Elysastræa Fischeri, *Laube*,

species which are common to the white dolomitic limestone of Sutton in Glamorganshire, and the St.-Cassian beds.

These widely ranging forms link the distant formations together in the

same manner as the fish which are found in the Triassic strata and also in the French zone of *Ammonites angulatus*. Not only are these species of Madreporaria not rare, but they are accompanied in the Sutton stone by closely allied species, which of course are allied to the St.-Cassian types.

Thecosmilia Suttonensis, Duncan, and *T. serialis*, Duncan, are in structure and in their methods of reproduction similar to *Thecosmilia rugosa*, Laube, a St.-Cassian species. *Elysastræa Fischeri*, Laube, is accompanied by a closely allied species in the Glamorganshire beds; and the genus is remarkable for its obvious connexion with the early secondary *Astræidæ* with more or less united walls.

Rhabdophyllia is a genus closely allied to *Thecosmilia*, and as the forms included in these genera commence as simple corals, and become compound or serial during growth, it is obviously necessary to compare them in their young stage with the genus *Montlivaltia*. Thus MM. Milne-Edwards and Jules Haime say that *Thecosmiliæ* are compound *Montlivaltiæ*; and this opinion is rendered important when it is remembered that some *Montlivaltiæ* have calycinal gemmation, and thus approach the Thecosmilian type still more. *Montlivaltia* is a genus with species in the lowest coralliferous secondary rocks; so that there is a fair assumption to be made that from *Montlivaltia* descended *Thecosmilia* and *Rhabdophyllia*. The *Thecosmiliæ* of the Sutton stone are principally capitate forms; that is to say, they spring from a peduncle and divide suddenly (by gemmation or by fissiparity). Amongst the non-capitate forms is *Thecosmilia rugosa*; moreover one of the species common in the French zone of *Ammonites angulatus* is also fissiparous and non-capitate, viz. *Michelini*, Terq. et Piette. *Thecosmilia Suttonensis*, Duncan, has some resemblance to *Thecosmilia rugosa*, Laube, in its calice, but not in its fissiparity, and it is allied to *Thecosmilia serialis*, Duncan, in its short peduncle and capitate swelling. The origin of the corallites in *T. Suttonensis* by intercalycinal gemmation is very distinctive.

Thecosmilia serialis, Duncan, belongs to the stunted *Thecosmiliæ* so characteristic of the Triassic and Lower Liassic coralliferous strata. It is readily distinguished by the number of corallites springing from the peduncle, and by its long serial calices mixed with rounded ones.

The existence of corallites produced, in one individual, by lateral gemmation, calicinal gemmation, and fissiparity is as remarkable as is the restriction of other individuals of different species to one of these forms of reproduction.

It is necessary to bear in mind that there are these diverse methods of gemmation and increase in these early *Thecosmiliæ*, because the genera which are structurally allied, and doubtless genetically related, possess one or more of these methods.

Moreover it is remarkable that the feeble true wall, the strong epithecate wall, the strong endotheca, the irregular septal arrangement, and the absence of true costæ should have existed in these old secondary forms, linking them on to the Palæozoic Coral-fauna in these particulars, whilst in Oolitic times the wall, costæ, and septa became developed according to the Mesozoic type. The gradation of structure between the species of the genus in consecutive periods, however, is very palpable.

Thecosmilia Martini and *Michelini* belong to the second series*; they are closely allied to each other and to several British species; they are bush-

* The species of the 1st series are marked *a* in the list of the British species.
" " 2nd " " *b* " " "
" " 3rd " " *c* " " "

shaped, and have a great range. It would appear that the following Table gives a correct idea of the dispersion of the early *Thecosmiliæ*.

St.-Cassian types ..	→ Azzarola, species ... / A. planorbis, species	→ Species of the Luxembourg and French Zone of *A. angulatus*.
	A. angulatus, species	→ Oolitic species.

The genus *Elysastræa* has its corallites separate and covered with an epitheca below, but united above at the calicular margin. The calicular part is clearly Isastræan, and the basal is Thecosmilian. Now bush-shaped *Thecosmiliæ*, such as *T. Michelini* and *T. Martini*, are noticed to become united by their walls in some individuals, and the walls of some species of genera closely allied to *Isastræa* are not united inferiorly.

The genus is clearly a transition, not only between *Thecosmilia* and *Isastræa*, but between several groups of genera. For instance,

Thecosmilia—Elysastræa—Isastræa—Latimæandræa.
Montlivaltia— *—Septastræa.*
—Prionastræa.

The earliest reliable *Isastrææ* are from St. Cassian; and several species are found with the St.-Cassian Elysastræan; but they are all erratic and rather abnormal forms. Thus *Isastræa Haueri*, Laube, and *I. splendida*, Laube, have a very irregular calicular development, and not one of the Liassic species ever attained that regularity of septal arrangement which characterizes the Oolitic Isastræans.

In the Sutton stone, at Brocastle, in Skye, and in the Worcestershire beds of *Ammonites angulatus*, there are the following *Isastrææ*.

Isastræa Sinemuriensis, *De From.*
—— globosa, *Duncan.*
Isastræa Murchisoni, *Wright*, sp.
—— Tomesii, *Duncan.*

I. Sinemuriensis	has deep calices, great irregularity of septal arrangement, 78 septa, sometimes no distinct cyclical arrangement.
I. globosa,	spherical, calices shallow, sometimes 36 septa, but no cyclical arrangement.
I. Murchisoni,	large, convex, flat, calices shallow; wall grows after the development of the contiguous calices; 40 or more septa; no cyclical arrangement.
I. Tomesii,	large, massive; wall thin; septa thin, with dissepiments between them visible; *not* 4 cycles.

The first of these species has a great range, and connects the St.-Cassian and Oolitic species with a high septal number.

The second belongs to a series comprising

I. Richardsoni, *Ed. & H.*, Inf. Oolite.
I. dissimilis, *Mich.*, sp. ,,

The third has evident affinities, from the structure of the wall, with *Elysastræa* and *Lepidophyllia*, and it is an unusual form.

The fourth resembles more or less *I. Bernardiana*, Ch. and Dew. Inf. Oolite.

It will be observed that these species have only a remote, but of course generic, affinity with the *Isastrææ* of the succeeding arenaceous deposits of the zone of *Ammonites Bucklandi*, but that their affinities with the species of the St.-Cassian and Inferior-Oolite coral-faunæ are decided.

They have only a generic relation to *Isastræa latimæandroidea*, Duncan, of the zone of *Ammonites planorbis*, as no serial calices are found in them.

There is a species of *Latimæandræa* in the British zone of *Ammonites angulatus*, *L. denticulata*, Duncan; its calices are very like the serial calices of *Isastræa latimæandroidea*.

I have already noticed that probably *Astrocœnia gibbosa*, nobis, is really a form from Azzarola, for the casts of both are very alike. Now there is an Astrocœnian in the St.-Cassian, *A. Oppeli*, Laube; it is unfortunately hardly specifically differentiated, but it is evidently closely allied to the *Astrocœnia* of the Sutton stone, as well as to *A. Sinemuriensis*, D'Orb., sp., from the French zone of *Ammonites angulatus*. This last species is also hardly sufficiently differentiated; but I have placed it amongst the British species provisionally.

There are eleven species of *Astrocœnia* special to the Welsh Lias, and the species just noticed. The genus was evidently flourishing in the St.-Cassian and Azzarolan times, and was singularly abundant in species amongst the Lower Liassic reefs at Sutton and Brocastle, to which the Mountain Limestone formed the support.

The Liassic *Astrocœniæ* occur as large and massive, small and dendroid, or as irregular and, sometimes, as incrusting forms. All the species are very irregular in their septal arrangements, and none of them present definite and clear cycles of septa.

Some of the species have the cœnenchyma between the calices irregularly ridged, so as to present the first traces of that cœnenchymal development which characterizes the genus *Stylocœnia*. The columella is very distinct in all the species, and the junction of the largest septa to it is marked in some forms by a paliform swelling; but there are no pali. The dentate condition of the septal edge is very marked. The size of the corallum, its shape and habit, the size of the calices, the character of the costæ, and the density, thickness, and ornamentation of the free portion of it appear to differ in various forms, and separate eleven new species from those already described.

The following is a scheme of the *Astrocœniæ* from the zone of *Ammonites angulatus*, at Sutton and Brocastle.

Astrocœnia.

Corallum......	large ...	gibbous and tall	Astrocœnia gibbosa, *Duncan.*
		flat and short	—— plana, *Duncan.*
			—— insignis, *Duncan.*
		short and irregular outline	—— septans, *Duncan.*
	small ...	incrusting	—— parasitica, *Duncan.*
		pedunculate, with epitheca ..	—— pedunculata, *Duncan.*
		dendroid	—— dendroidea, *Duncan.*
		flat and narrow	—— superba, *Duncan.*
		globose..........................	—— favoidea, *Duncan.*
		irregular	—— costata, *Duncan.*
		flat and semiincrusting	—— minuta, *Duncan.*

Corallum having the cœnenchyma	scanty	Astrocœnia favoidea.
		—— minuta.
	abundant..................	—— parasitica.
		—— dendroidea.
		—— superba.
		—— pedunculata.
		—— insignis.
	moderately developed	—— septans.
		—— costata.
		—— gibbosa.
		—— plana.

The surface of the cœnenchyma ...	ornamented...	and straight...	Astrocœnia insignis.
		" spined ...	—— superba.
		" wavy......	—— costata.
			—— gibbosa.
	ridged		—— gibbosa.
			—— plana.
			—— minuta.
			—— reptans.
			—— dendroidea.
	plain		—— parasitica.
			—— pedunculata.
	rudimentary		—— favoidea.

Astrocœnia clavellata, Terq. et Piette, is found in the Luxembourg Lower Lias, but the zones above that of *Ammonites angulatus* in the Lias do not present, as yet, any species. The species is represented in the Oolites, and became extinct in the Falunian.

Cyathocœnia is a new genus, which I have suggested and published in order to admit forms which, had they been furnished with a columella, would have been classified as *Astrocœniæ*. There is a species in the zone of *Ammonites Bucklandi*. Some of the species are mimetic of the *Astrocœniæ*. The following is a scheme of the genus.

Cyathocœnia.

Cyathocœniæ with the corallum	branching, having costæ	C. dendroidea.
	incrusting, no costæ, cœnenchyma granular	C. incrustans.
	flat large costæ, and a deep calice	C. costata.
	globular, no costæ, cœnenchyma plain..................	C. globosa.

The gradation of structure in the genera just passed under our notice becomes more and more evident as such forms as those included under the genus *Cyathocœnia* are studied. In the early stage *Thecosmilia* cannot be distinguished from *Montlivaltia*; but gemmation from the calice, from the calicular wall, or from the wall ensued, or fissiparous division occurred, as the corals grew. There was an evident tendency in *Montlivaltia Walliæ*, Duncan, for instance, to reproduce by calicular gemmation; but in *Oppelismilia* distinct calicular budding occurred. Under these circumstances the genetic relations of the three genera *Thecosmilia, Montlivaltia*, and *Oppelismilia* are of the closest.

Now in bush-shaped *Thecosmiliæ* union often occurs between a bud from the wall and the parent stem. A section transverse to the line of growth shows, (1) low down, two corallites with their septa, walls, and epitheca perfect; but higher up the epitheca is not seen in a section, and the walls may be (2) slightly separate, or (3) quite fused, and they then appear as one lamella between the corallites.

(1) is what is observed in *Elysastræa*; (2) is the Septastræan peculiarity; (3) peculiarizes *Isastræa*.

The origin of *Latimæandræa* from *Isastræa* has already been noticed. In *Elysastræa* the epitheca and one wall become absorbed at the calicular margin. In *Cyathocœnia* the epitheca between the walls becomes cœnenchymal, and variously ornamented; whilst in *Astrocœnia* the same thing occurs besides the growth of a columella.

The following grouping of the genera is made with a view to assert that they had genetic relations with *Montlivaltia*, and that some Cainozoic types revert to more ancient.

Montlivaltia	Oppelismilia.		
	Thecosmilia.		
Thecosmilia with	gemmation from the wall	Elysastræa	Cyathocœnia.
		Phymastræa (*a*) ..	Astrocœnia.
		Solenastræa (*b*) ...	Thamnastræa.
		Heliastræa (*c*)	Isastræa.
			Prionastræa.
			Astræa.
			Metastræa.
	calicular gemmation	Lepidophyllia.	
	serial calices	Latimæandræa.	
	fissiparous development...........	Septastræa.	

a. An evident reversion to *Elysastræa* in a recent genus.

b. *Solenastræa* is a case of reversion to an ancestral *Thecosmilio-Elysastræa* type in the later Neozoic ages.

c. Has great probability of being a case of atavism with much modification of *Thecosmilia* and *Solenastræa*.

The *Montlivaltiæ* of the zone of *Ammonites angulatus* are remarkable for their septal regularity, the amount of dissepimental endotheca, the usually rudimentary condition of the true wall, and the development of the strong and compensating endotheca. These characteristics are observed in the St.-Cassian *Montlivaltiæ*, and in those which are found in the strata intervening between the *Ammonites-angulatus* and the St.-Cassian beds. These structural peculiarities, in a genus whose later Jurassic species have a perfect hexameral arrangement, a perfect wall, and moderate endotheca and epitheca, indicate the descent of the *Montlivaltiæ* from a Palæozoic stock. In *Montlivaltia Murchisoni*, Duncan, the wall and epitheca are united perfectly into one structure with the *intercostal spaces,* just as the septa of some simple Palæozoic corals are continuous, not with costæ, but with the intercostal spaces or their analogues.

M. parasitica is remarkable for its septal number; and *M. simplex* has distant and curved septa.

M. papillata, Duncan, *M. Hiberniæ*, Duncan, and *M. Haimei*, Chap. et Dew., are closely allied species; they are broad-based, pedunculate, short, and turbinate, and vary greatly. The last-named species ranges probably over the whole area of the zone of *Ammonites angulatus.*

Closely allied to *Montlivaltia* and *Thecosmilia* is the new genus *Oppelismilia*. Its Palæozoic aspect is distinct, the multiseptal and non-cyclical calice, the calicular budding, and the strong epitheca all refer it to bygone types.

These corals, from the Lias beneath the zone where *Gryphæa incurva* and *Ammonites Bucklandi* are abundant, indicate that, like the succeeding formations of the Chalk and the Oolite, the Lias was very coralliferous. Nothing marks the progress of palæontology more strongly than the ability of making this statement from well-ascertained data; for within a very few years the Lias was considered so muddy a deposit as to be obnoxious to coral life.

Now, with a great fauna, part of it indicating reef conditions and the rest moderately deep water, the Lower Lias will assume as great an importance to the zoophytologist as the Eocene. The Liassic coral-fauna reflects the Palæozoic as the Eocene foreshadows the Recent coral-fauna. Unfortunately the paucity of our information respecting the earliest Secondary coral-fauna, that of the Lower Trias, is so great that the Liassic species are still greatly removed from the original types.

Corals from the Zone of Ammonites Bucklandi (bisulcatus).

Corals are not numerous as regards their species in this zone, and the com-

monest species of the zone of *Ammonites angulatus* have not been found in any of its strata.

It is probable that *Thecosmilia Martini*, E. de From., which in France ranges from the beds containing *Ammonites Moreanus* into those in which *Ammonites bisulcatus* is found, has a corresponding vertical range in England. *Thecosmilia Michelini*, Terq. et Piette, appears to be present in the zone of *Ammonites bisulcatus*; but as yet only casts of its specimens, which resemble those of the species from Abbot's Wood in the zone of *Ammonites angulatus*, have been found. These casts, and some of *Thecosmilia Martini*, have been assigned to the genus *Cladophyllia*, but without sufficient reason. *Thecosmilia* is a large genus, and of course the species present individuals of all sizes; so that to give to small cylindroid *Th cosmiliæ* the generic appellation of *Cladophyllia* is unreasonable. In fact this last genus is but a subgenus of *Thecosmilia* at the best.

List of Species from this Zone.

1. Montlivaltia Guettardi, *Blainville.*
2. Septastræa Eveshami, *Duncan.*
3. Lepidophyllia Stricklandi, *Duncan.*
4. Isastræa endothecata, *Duncan.*
5. Isastræa insignis, *Duncan.*
6. —— Stricklandi, *Duncan.*
7. Cyathocœnia globosa, *Duncan.*

Septastræa Eveshami has very irregular calices; and when the wall has been worn away between them, a groove is seen indicating that separation of the corallites which I have already noticed to obtain in the *Elysastrææ*. The species is rather abnormal; for although fissiparity is common, still there is a disposition to serial increase.

The genus *Isastræa* has three well-marked species in this zone, and they are very distinct from those of the zone of *Ammonites angulatus*. In *Isastræa endothecata* the depth of the calices, the extraordinary development of the endotheca, and the great number and the irregularity of the septa are differential. *Isastræa Stricklandi* also has a great development of endotheca; for large plates of it cross the corallites, and shut in the calicular fossæ below, acting perfectly like tabulæ, just as in *Cyathaphora*. The septa are few in number; and no cyclical arrangement is to be noticed.

Isastræa insignis belongs to a section of the genus which comprises *I. Henocquei*, Ed. & H., from the Hettangian, *I. polygonalis*, Muschelkalk, and *I. Lonsdalei*, Ed. & H., from the Inferior Oolite.

A new genus, *Lepidophyllia*, has a species in this zone, and a very fine one in the zone of *Ammonites Jamesoni*: it is an interesting form, and presents some Rugose characteristics, such as a repeated calicular gemmation and an epithecate wall.

The only *Montlivaltia* I have seen from the zone of *Ammonites Bucklandi* has a lower horizon on the continent. Having thus a very considerable vertical and geographical range, the species is, of course, very variable, and many local varieties have been found, which are separated with difficulty from *Montlivaltia Haimei*. These flat multiseptate *Montlivaltiæ* are very characteristic of the Lower Lias. They have a representative in the zone of *Ammonites obtusus*, in the form of *M. patula*, Duncan, whose dentate septa are wonderful. Such septa began then to be the fashion; for in the next zone the *Montlivaltiæ* are famous for their grandly ornamented dentations.

Corals from the Zone of Ammonites raricostatus.

The *Montlivaltiæ* from Fenny Compton, Honeybourne, and Cheltenham belong to several species, and two of these are singularly polymorphic. Shape has not much to do with the specific diagnosis of some recent simple

corals; and it is necessary to assert this in collecting under one fossil species corals of very different external forms. The *Montlivaltiæ* from the zone of *Ammonites raricostatus* are common, and their mineral condition has been preservative of the minutest details: even the granulations on the minute septal dentations are preserved.

Dr. Wright collected and described a very remarkable series of corals from the Hippopodium and coral-beds of Marle Hill, Cheltenham, Honeybourne, and Fenny Compton, naming them *Thecocyathus rugosus*. The assemblage of forms thus named contains very varied specimens, the external shape especially being rarely alike in two or three instances. A careful examination of sections of most of the forms enabled me to place them all in the genus *Montlivaltia*. The absence of pali and the presence of short endothecal dissepiments proved that they could not belong to the genus *Thecocyathus*. But the general Montlivaltian characteristics have also the palæozoic peculiarities already noticed in considering the *Montlivaltiæ* of the zone of *Ammonites angulatus*. *Montlivaltia rugosa*, Wright, sp., will therefore take the place of *Thecocyathus rugosus*, Wright, MS.

Montlivaltia mucronata, Duncan, is a polymorphic species, remarkable for its elegance and ornamentation; some of its specimens are amongst the most beautiful of the *Madreporaria*. The study of a large collection enabled me to place some very different-looking forms in the same species, the intermediate varieties having been in my possession.

There is a decided affinity between these *Montlivaltiæ* and *M. Stuchburyi*, Ed. & H., of the Inferior Oolite. Moreover the *M. nummiformis*, Duncan, of this zone is related, if structural affinity be of value, to *M. lens*, E. & H., Inf. Oolite. *Montlivaltia radiata*, Duncan, is a very abnormal species, and retains the quadrate septal arrangement, which is fully represented in many Liassic species, but which is so characteristic of many Palæozoic forms. It must be remembered that such strange structural peculiarities in later forms may arise from atavism.

List of Corals from the Zones of the Lower Lias above the Zone of Ammonites Bucklandi.

Montlivaltia patula, *Duncan.*
—— rugosa, *Wright*, sp.
—— mucronata, *Duncan.*
Montlivaltia nummiformis, *Duncan.*
—— radiata, *Duncan.*

There are then twelve species in the Lower Lias above the zone of *Ammonites angulatus*, five of which are above the zone of *Ammonites Bucklandi*. It needs no care to decide that the fauna of the zone of *Ammonites angulatus* has little affinity with that of the other zones.

Corals from the Middle Lias.

1. *Lepidophyllia Hebridensis*, Duncan.
2. *Montlivaltia Victoriæ*, Duncan.

The first species is from the island of Pabba, and was collected by Dr. Wright; it forms a bed there, and was doubtless a rapid grower.

The genus has already been slightly noticed; its calicular gemmation and the growth of epitheca on the free wall of the corallites, where they grow higher than their neighbours, refer to an Elysastræan, Thecosmilian, and Septastræan series.

A great number of specimens of all sizes of a very polymorphic *Montlivaltia* have been found on the surface of the fields at Chemington, near Skipton, and in a watercourse or ditch section of the Middle Lias close by. *Ammonites*

Henleyi, *A. Chiltensis*, *Cardinia attenuata*, and *C. elongata* were found with the corals.

Montlivaltia Victoriæ, Duncan. This coral grows to a height of five inches, and may be two inches broad; it is the largest simple secondary form, and has the epithecal wall so peculiar to the Liassic *Montlivaltiæ*. Its septal number is very great, and the endotheca is highly developed. It is very variable in shape.

There are some fragmentary corals in the Marlstone, but their genera are doubtful; and the cast of a *Montlivaltia* was found by Mr. Charles Moore at Wells, but I cannot determine the species.

Corals from the Upper Lias.

The only species is that which was found years since, and which was described by MM. Milne-Edwards and Jules Haime, *Thecocyathus Moorei*, Ed. & H.

Total number of Species of Corals from the British Liassic Strata.

Lower Lias	64 species.
Middle Lias	2 ,,
Upper Lias	1 ,,
	67 species.

The descriptions and drawings of sixty-six of these species are in my 'Monograph of the Liassic Corals,' 1867, 1868, Pal. Soc.

The *Thecocyathus Moorei*, Ed. & H., was described and drawn in the 'Monog. Oolitic Corals,' by Milne-Edwards and Jules Haime, Pal. Soc.

Report of a Committee appointed to investigate Animal Substances with the Spectroscope. *By* E. Ray Lankester.

During the year attempts have been made to obtain a supply of Siphonostoma or *Sabellæ* for the purpose of investigating the derivatives of the body described by me last year as chlorocruorine; at present a sufficient supply has not been obtained. The absorption-spectrum of chlorocruorine from *Sabella*, however, has been carefully observed and recorded. The Sponge-chlorophyll has been investigated with the object of determining which of the two green and two yellow bodies, spoken of by Professor Stokes as being present in plants, is present in the sponge; and some interesting results appear likely to be obtained when the history of plant-chlorophyll is more fully known.

The feathers of twenty-two species of birds, mostly red, green, or blue, have been examined for absorption-spectra; none was obtained; but Prof. Church has discovered a red matter containing copper in the feathers of the Turacou; and to this body he gives the name turacin. The spectrum of this substance I have carefully examined and recorded. As stated by Prof. Church, it gives two absorption-bands, when in the feather, close to those of hæmoglobin, but readily separable from them, and by no means indicating anything like identity in the bodies, as Prof. Church appears to have thought.

A scheme with the chief solar lines and Sorby's standard interference lines

ruled in has been prepared for recording absorption-spectra. I have taken notes of many by this means, which is very useful. A more satisfactory means of measurement than Sorby's scale appears to be required, since the quartz plate cannot be readily obtained of the right thickness.

In a future Report I hope to give the results of observations which have now to be deferred.

Second Report of the Committee on the Condensation and Analysis of Tables of Steamship Performance.

At the Dundee meeting of the British Association in 1867, the Committee on the above-mentioned subject, consisting of John Scott Russell, Esq., F.R.S., William Fairbairn, Esq., LL.D., Thomas Hawksley, Esq., C.E., James R. Napier, Esq., F.R.S., and W. J. Macquorn Rankine, Esq., LL.D., was reappointed, for the purpose of continuing its duties as defined in the resolution by which it was originally appointed in 1866; and a sum of £100 was placed at its disposal. The Committee, as before, employed Mr. J. Quant, naval architect, as calculator, and have reason to be highly satisfied with the manner in which his duties have been performed.

The sum of £100 has been expended.

The contents of the Report now submitted to the Association are as follows:—

List of detailed tables whose condensed results appear in the present Report.

Condensed tables.

Analyzed tables, according to the method of Mr. Scott Russell.

Analyzed tables, according to the method of Professor Rankine, so far as that method is at present complete; that is to say, taking into account eddy-resistance depending on friction, and wave-resistance due to shortness of afterbody. Just at the commencement of the Meeting to which this Report is presented, Professor Rankine pointed out a hitherto neglected kind of wave-resistance, depending on a relation between speed and depth of immersion; but the data of observation necessary in order to determine its amount and laws have not yet been obtained.

In explanation of the distinction between "condensed" and "analyzed" tables, it has to be stated that the condensed tables contain nothing except quantities ascertained by measurement, observation, and experiment; while the analyzed tables contain certain functions of those quantities, which functions are connected with theoretical views as to the probable nature and laws of the actions that take place between the vessel and the water.

List of Detailed Tables whose condensed results appear in this Report.

The detailed tables whose condensed results appear in the present Report consist of those which were published in the Report of the British Association, 1863.

Table I.—Engineer's log of City of Dublin Steam Packet Company's Steamship 'Munster,' June and July, 1861.

No information as to draught of water or displacement is given.

Table II.—Abstract of the log of the Pacific Steam Navigation Company's Royal Mail Steamship 'Quinto' from Liverpool to St. Vincent, 1864.

No dimensions of the ship are given.

Table III.—Royal (West-India) Mail Packet Company, Southampton to St. Thomas, distance 3622 miles, from July 2nd, 1862, to June 2nd, 1863.

This Table contains the performance of five ships, the 'Atrato,' the 'Shannon,' the 'Seine,' the 'Tasmanian,' and 'La Plata.' No draft of water is given, but the condition of the hull is stated.

Table IV.—Royal (West-India) Mail Packet Company, St. Thomas to Southampton, July 30th, 1862, to June 30th 1863.

This Table contains the same steamers as the preceding. Table III. contains the performance of those ships on their outward voyage, and Table IV. their performance on their homeward voyage, during twelve months' work. No draft of water on leaving port, nor area of midship section has been given, although mean displacement has been stated.

Table V.—Royal (West-India) Mail Packet Company. Summary made from the Tables of diagrams from indicator and working of the engines belonging to the various ships included in the return furnished of the performances from St. Thomas to Southampton, between July 30, 1862, and June 30, 1863, as given in Table IV.

This Table contains very useful data; the quantities of two ships have been reset and repeated in this condensed Report, and as far as possible the lines of the ships have been obtained, and the draft of water and area of midship section corresponding to the mean displacement are inserted in the condensed Tables.

Tables VI., VII., VIII., and IX. contain abstracts of engineer's log of the 'Great Eastern.'

The indicated horse-power has been given in Table IX. only; and therefore that performance only is available for calculation.

Table X.—Abstract of engineer's log of the Steamship 'Great Eastern,' eighteen voyages, 1860–1863.

No statement has been made of indicated horse-power.

Table XI.—Return of H.M. Steam Line-of-Battle Ship 'Victor Emmanuel.'

This Table contains twenty-seven runs, of which sixteen were made under steam. Quantities of the vessel have already been given in last year's condensed Report, Table V. Her performance appears in this Report under different conditions of draft of water and displacement, and consumption of coals.

This Table has been condensed to eleven runs under different conditions; and, although not strictly according to the form laid down in last year's Report for the condensation of tables, it has been thought proper to insert the whole of the items given in the Report of 1863, so as to form a Table by itself. The indicated horse-power as given in the condensed Table has been calculated from the indicator-diagrams as published in the Report of 1863. This is the only one of the condensed Tables in which the degree of expansion of steam has been given. It is much to be desired that the lines of this vessel, as also those of other ships of war, should be obtained from the Admiralty, in order to furnish data for analysis.

Table XII. and XIII.—Résultats de la navigation des Paquebots des Services Maritimes des Messageries Impériales, pendant l'année 1861 et 1862.

No particulars of these ships have been given, with the exception of the draft of water.

Table XIV.—Particulars of 12 steamers indicated by letters of reference (A to K).

No area of midship section nor displacement has been returned.

Table A.—Particulars of the trial trips of four Holyhead Mail Steamers 'Banshee,' 'Llewellyn,' 'Leinster,' and 'Connaught,' in comparison with H.M.S. paddle-yacht 'Victoria and Albert.'

This Table does not mention the displacement of the ships. Where it has been possible these quantities have been filled up from the lines and from other sources of information.

Report 1863 contains two Plates showing indicator-diagrams of H.M.S. 'Victor Emmanuel' (fore-cylinder and aft-cylinder).

The pressure of steam in the cylinders, and the indicated horse-power as calculated by these diagrams, are given in Table IX. of this Report.

Of the five Royal (West-India) Mail Packet Company's Steamships whose performances were published in Tables III., IV., and V., Report 1863, the performances of two have been condensed and inserted in this Report, viz. the 'Atrato' (paddle), built by Messrs. Laird and Co., and the 'Tasmanian' (screw), by Messrs. Laurence Hill and Co.

The nominal horse-power of the screw-steamer 'Tasmanian' is given as 744 in Report of 1863, and 550 in earlier printed Tables. In earlier Tables the nominal power of the 'Atrato' is given as 800, whereas in the Report of 1863 it has been published as 766. Further, it appears that the indicated horse-power, as given in the condensed Report of 1867, is the I. H. P. as measured in *one* cylinder only, in the case of the paddle-steamers 'Atrato,' 'Shannon,' and 'La Plata.'

Condensed Tables.

Performance of two Royal (West-India) Mail-Packet Company's Steamships on a voyage of 3622 miles.

Names	Atrato, paddle.	Tasmanian, screw.
Length on load water-line, in feet	336·5	332·
Breadth (extreme), in feet	40·92	39·
Mean draft of water, in feet	18·35	19·8
Area of immersed midship section, in sq. ft.	653·	666·
Displacement, in tons of 35 cubic feet	3979·	3760·
Mean immersed girth, in feet	52·54	52·52
ENGINES.		
Description	Side lever.	Tr. inverted.
Number of cylinders	2	3
Diameter of cylinders, in inches	96·	68·
Length of stroke, in feet	9·	3·5
Number of revolutions, per minute	14·42	41·76
Average steam as per card, in lbs.	6·547	5·137
Average vacuum as per card	11·181	9·712
Pressure of steam as per gauge, in lbs.	13·41	15·1
Vacuum as per gauge, in inches	26·	25·95
Nominal horse-power	800·	550·
Indicated horse-power from one cylinder	2207·98	1442·19
Coals consumed, in lbs. per hour	7936·	6896·
Speed of ship, in knots per hour	11·22	10·67

From "Particulars of Trial Trips, Table A," Report 1863, in which the performance is given of the four vessels on the Mail Service between Dublin and Holyhead with a voyage on the same route of the 'Victoria and Albert,'

only the performance of the 'Leinster' and Her Majesty's yacht has been extracted and given in this Report.

In studying the quantities of these mail-boats, it was found that in Report 1861, Table IX., the nominal power of 'Leinster' is given as 750, whilst in Report 1863 it is printed as 720. Again, in Report 1861 the diameter of the wheel is given as 33 feet outside the floats, and 29 feet to centre of journals, whilst in Report 1863 the diameter is given as 31 feet outside floats, and 27 feet to centre of journals—a difference therefore of 2 feet in each case. Further, in Report 1861 the quantities of the 'Leinster' and 'Ulster' are given under one bracket, leading to suppose that those two ships are alike in all respects, whereas such is not the case. The diameter of cylinders of both ships is given in that Report as 96 inches with a stroke of 7 feet, whilst in the Report of 1863 the diameter of cylinder of the 'Leinster' is printed as 98 inches, with 6 feet 6 inches stroke, and that of the 'Ulster' as 96 inches, with 7 feet stroke.

In order therefore to ascertain the truth it was necessary to write to the manufacturer of the engines; and the correct quantities of the 'Leinster' are given in the Table below.

In making the condensed Report of last year, the Report on Steamship Performance of 1863 was not in the calculator's hands, and the quantities of the 'Leinster,' therefore, were given as he found them in former Reports; but by a comparison with the Table below the errors may be corrected. The displacement, as here given, and which was not mentioned in Report 1863, has been calculated from the lines.

Names	Leinster.	Victoria and Albert.
Length, in feet	327·	300·
Breadth, in feet	35·	40·27
Draft of water, in feet	12·68	13·92
Area of immersed midship section	336·	401·
Displacement, in tons of 35 cubic feet	1675·	1980·
Mean immersed girth, in feet	40·18	40·
ENGINES.		
Description	Oscillating.	
Number of cylinders	2	
Diameter of cylinders, in inches	98·	
Diameter of air-pump, in inches	54·	
Stroke of cylinder, in feet	6·5	
Stroke of air-pump	2·5	
Number of revolutions, per minute	26·25	25·4
Nominal horse-power	720·	600·
Indicated horse-power	4751·	2980·
Speed of vessel, in knots	17·747	16·827
Speed of vessel, in statute miles	20·429	19·377
Pressure of steam by safety-valve, in lbs.	25·	23·
Vacuum in condenser, in inches	25·	25·
Diameter of wheel outside float, in feet	31·	
Diameter of wheel to journals	27·	

Table IX.—Condensed Table of trials of H.M. Steam Line-

Date of trial	March 16.	March 24.	March 25.	March 26.
Ship's course	S.W. by W.	W. by N.	W. ½ N.	W. ½ S.
Wind's direction	Westerly.	Southerly.	N.E.	S.W.
Wind's force	1	1 to 2	0 to 1	1 to 3
State of sea	Smooth.	Smooth.	......	Slight swell.
Mean draft of water	23·54	23·54	23·54	23·46
Displacement, in tons	5000·	5000·	5000·	4970·
Area of midship section, in square feet	1040·	1040·	1040·	1035·
Average speed per hour, in knots	6·8	8·05	6·57	6·7
Duration of trial, in hours	8·	8·	4·	9·
Steam cut off in proportion of stroke	$\frac{1}{10}$	$\frac{1}{8}$	$\frac{1}{10}$	$\frac{1}{10}$
Average number of revolutions	35·	40·	35·	36·
Pressure of steam near cylinder, in lbs.	16·	17·	16·	17·
Mean pressure on piston, in lbs.	9·61	12·71	9·9	9·95
Barometer (fore), in inches	23½	25·	25·	24½
Barometer (aft), in inches	24½	25·	25·	24½
Indicated horse-power	649·4	1006·5	730·7	691·5
Speed of screw, in knots per hour	8·94	10·22	8·94	9·2
Slip, in knots per hour	2·14	2·17	2·37	2·5
Slip, per cent.	23·9	20·6	26·5	27·1
Number of furnaces at work in the boiler	10·	15·	10·	15·
Grate-surface at work, in square feet	217·5	326·25	217·5	326·25
Heating surface at work, in square feet	5726·6	8589·9	5726·6	8589·9
Pressure of steam in the boilers, in lbs.	16·	17·	16·	17·
Consumption of coals, in cwt. per hour	23⅛	31⅞	24·	33·
Consumption of coals, in cwt. per knot	3·4	3·95	3·65	4·92
Consumption of coals, per I. H. P. per hour	3·9	3·5	3·6	5·3
$\frac{V^3 \times \oplus}{\text{I. H. P.}}$	503·	539·	403·	450·
$\frac{V^3 \times D^{\frac{2}{3}}}{\text{I. H. P.}}$	141·	151·	113·	126·
Distance run with 1 ton of coals	5·88	5·05	5·47	4·06
Description of sail set	......	......	......	......
Area of sail set, in square feet	......	......	......	......
Remarks	......	Foul bottom.	Foul bottom.	......

of-Battle Ship 'Victor Emmanuel' during the year 1862.

March 29.	March 30.	April 5.	March 25.	April 1.	April 6.	April 6.
S.W. ½ S.	W.N.W.	N.W. ½ W.	W. ½ N.	W.	N.W. ½ W.	N.W.
W.S.W.	S.W. by W.	N.W.	E.N.E.	N.W. by W.	N.N.E.	N.E.
1	6 to 7	3	3 to 4	2 to 3	2 to 3	2 to 3
Heavy swell, S.W.	......	Smooth.	Slight swell.	Moderate swell.	Moderate swell.	....
23·35	23·29	23·33	23·54	23·27	23·22	23·221
4923·	4910·	4925·	5000·	4903·	4887·	4887·
1030·	1026·	1029·	1040·	1025·	1024·	1024·
6·0	6·82	6·5	8·5	8·02	7·6	7·2
5·	6·	4·	3·	3·	7·	5·
·158	·307	$\frac{1}{6}$	$\frac{1}{10}$	$\frac{1}{8}$	$\frac{1}{10}$	$\frac{1}{12}$
42·	46·	43·	38·	42·	38·	31·
18·	18·	17·	16·	17·	17·	16·
12·66	15·26	12·04	9·98	11·9	9·6	7·91
24·	24½	24½	24·	25½	25·	24·
24·	24½	24½	24·	24½	23·	23½
1026·6	1355·8	999·6	730·7	965·0	704·4	473·4
10·73	11·75	10·99	9·71	10·73	9·71	7·92
4·73	4·93	4·49	1·21	2·71	2·11	0·72
44·1	41·9	40·8	12·5	25·3	21·7	9·
15·	20·	10·	10·	15·	15·	15·
326·25	435·	217·5	217·5	326·25	326·25	326·25
8589·9	11453·2	5726·6	5726·6	8589·9	8589·9	8589·9
18·	18·	17·	16·	17·	17·	16·
$35\frac{4}{5}$	$65\frac{2}{3}$	46·	32·	$54\frac{2}{3}$	34·	$22\frac{2}{5}$
5·96	9·62	7·07	3·76	6·81	4·47	3·11
3·9	5·4	5·1	4·9	6·1	5·4	5·7
216·	240·	282·	874·	547·	638·	808·
61·	67·5	79·5	246·	154·	178·	227·
3·35	2·08	2·82	5·31	2·93	4·47	6·421
......	......	......	Plain sail to single reefed top-sail.	Fore- and aft-sails.	Fore- and aft-sails.	All sail to fore-top and fore-top-gallant and studding sails.
......	......	......	2631·	1126·	1126·	3649·
Bad coals; hip pitching heavily.	......	......	Foul bottom.	Foul bottom.	......	....

Example of Analyzation according to the method of Mr. Scott Russell.

Royal Mail Steamship 'Atrato.'

Length on load water-line, in feet	336·5
Breadth, in feet	40·92
Mean draught of water without keel	18·35
Area of immersed midship section, in square feet	653
Displacement in tons of 35 cubic feet	3979
Diameter of paddle-wheel outside floats, as taken from the drawing, in feet	36·5
Diameter of wheel to journals in feet or effective diameter	32
Indicated horse-power	2207·98
Speed of ship in knots per hour	11·22
One knot being = 1·69 feet per second, hence speed of ship in feet per second	18·96
Consumption of coals, in lbs. per hour	7936
Coefficient of fineness of midship section or $653 \div B \times d =$	0·869
„ „ body or $3979 \times 35 \div B \times d \times L =$	0·5512
„ „ ends or D in cubic feet $\div \oplus \times L =$	0·6339
„ performance $V^3 \times D^{\frac{2}{3}} \div$ I. H. P.	160·62
„ „ $V^3 \times D^{\frac{2}{3}} \div W$	5005

W in this formula means consumption of coals in cwt. per hour.

Coefficient of performance $V^3 \times \oplus \div$ I. H. P.=	419·66
Revolutions of paddle-wheel per minute	14·42
Velocity in paddle-wheel, in knots per hour	14·29

To find the velocity of the paddle-wheel, the effective diameter has been multiplied by 3·1416; this product has been multiplied by the number of revolutions per minute, this product again by 60, and the last product has been divided by 6082·66 to find as quotient the velocity in knots per hour.

Slip in knots per hour equal to 14·29—11·22 =	3·07
Slip in feet per second equal to $3·07 \times 1·69$ =	5·19
Speed of ship : speed of slip : : 1 :	0·27
Dip of paddle-board, measured from lower edge, in feet	9
Length of paddle-board, in feet	12
Area of paddle-race $12 \times 9 \times 2$, in square feet	216
Area of midship section : Area of paddle-race : : 1 :	·33

Resistance due to area of paddle-race equal to speed of slip, in feet per second², multiplied by the area of paddle-race, or

$$5·19^2 \times 216 = 5818 \text{ lbs.}$$

Resistance due to length of paddle-race equal to resistance due to area of paddle-race multiplied by the speed of the ship ÷ speed of slip, or 21,263 lbs.

Coefficient of diminished resistance.—This coefficient belongs to a pure-mathematical wave-line bow. The question offers itself, what is the length of this bow?

The length of the bow of the ship can be denoted

1. By the speed,
2. By the place of half the beam in the light water-line,

3. By the coefficient of fineness of ends, and
4. By the actual length as found by the lines.

For the afterbody the length would be $\frac{2}{3}$ of the above quantities, with the exception of 4, where it is given by the lines. 1, 2, 3, 4 worked out for the 'Atrato' would give a length of bow as computed by

1. 70·16 feet *
2. 80 „
3. 176 „
4. 166 „

quantities which differ immensely. But whatever the length of forebody, afterbody, and middlebody may be as computed above, the *three* together *must* form the given displacement with the given draught of water. The wave-line method supplies formulæ by means of which the exact length of bow answering both conditions may be found; and in order to prove which of the four quantities is correct we proceed as follows:—

Let p denote the coefficient of fineness of midship section,
q the coefficient of fineness of body,
r the coefficient of fineness of ends equal to $q \div p$; then

volume of forebody equal to $\cdot 5\,\mathrm{B}ldp = \cdot 5\,l \times \oplus$
„ afterbody „ $\cdot 5\,\mathrm{B}l'dp + \cdot 19635\,\mathrm{B}^2dp = (\cdot 5\,l' + \cdot 19635\,\mathrm{B})\oplus$
„ middlebody „ $\mathrm{B}l''dp = l'' \times \oplus$
total displacement „ $\cdot 5\,\mathrm{B}ldp + \cdot 5\,\mathrm{B}l'dp + \cdot 19635\,\mathrm{B}^2dp + \mathrm{B}l''dp.$

Dividing this by the parallelopiped, B Ld, will give the coefficient of fineness of body, or q,

$$\cdot 5l + \cdot 5l' + \cdot 19635\mathrm{B} - l'' = \frac{q}{p}\mathrm{L} = r\mathrm{L}; \text{ but } l + l' = \mathrm{L} - l'';$$

$$\text{hence } \cdot 5\mathrm{L} + \cdot 5l'' + \cdot 19635\mathrm{B} = r\mathrm{L},$$

from which equation l'', or the length of the middlebody, may be determined; and having the length of the middlebody deducted from the total length of the ship, six-tenths of the remainder will give the length for the forebody, and four-tenths of the remainder will give the length of the afterbody.

Working the above formula out for the 'Atrato' we shall get

$$\cdot 5 \times 336\cdot 5 + \cdot 5l'' + \cdot 19635 \times 40\cdot 92 = \cdot 6339 \times 336\cdot 5,$$
$$\cdot 5l'' = 37\cdot 02, \text{ or } l'' = 74\cdot 04 \text{ equal to length of middlebody.}$$

hence length of forebody equal to $\cdot 6(336\cdot 5 - 74\cdot 04) = 157\cdot 476$,
and length of afterbody „ $\cdot 4(336\cdot 5 - 74\cdot 04) = 104\cdot 984$.

It will be seen from these quantities that already twice as long a bow has been obtained as is necessary for a speed of 11·22 knots.

Let us now test these quantities for the displacement.

* A curve is appended at the end of this Report, by which for any given speed in statute miles the length of bow and stern might be measured.

Forebody.

Log 653	=2·8149132
Log 157·476	=2·1972144
Log ·5	=9·6989700
	4·7110976
Log 35	=1·5440680
	3·1670296
Nat[l] n[r]	= 1469 tons

Afterbody.

Log 653	=2·8149132
Log 104·984	=2·0211066
Log ·5	=9·6989700
	4·5349898
Log 35	=1·5440680
	2·9909218
Nat[l] n[r]	= 979·3 tons
Log ·19635	=9·2930309
Log 40·92	=1·6119356
Log 653	=2·8149132
	3·7198797
Log 35	=1·5440680
	2·1758117
Nat[l] n[r]	=149·9

Middlebody.

Log 653	=2·8149132
Log 74·04	=1·8694664
	4·6843796
Log 35	=1·5440680
	3·1403116
Nat[l] n[r]	=1381

1469+979·3+149·9+1381=3979·2 tons, or just two-tenths of a ton more than the actual displacement. Now there is no length of forebody, afterbody, and middlebody possible that will fulfil the conditions required; and it would therefore be wrong to compute the length of forebody in any other way than through means of the coefficient of fineness of ends. The 'Atrato' has no *actual* middlebody; but we see that she really could have had a parallel middlebody of 74 feet without in the least injuring her qualities.

The length of forebody, afterbody, and middlebody, through means of the mentioned formulæ, have been calculated for several ships, and the result has been appended in a Table which follows the Table of Analysis according to Mr. Scott Russell's method.

It will easily be seen that this length of middlebody varies with the draft of water; the lighter the vessel is, the shorter the middlebody, and the deeper the vessel the longer the middlebody, the different coefficients of fineness necessarily becoming smaller when light, and larger when laden.

The coefficient of diminished resistance is therefore $(40{\cdot}92 \div 157{\cdot}476)^2 = 0{\cdot}0675$.

Resistance due to ship's way, equal to area of midship section multiplied by the square of the speed of the ship in feet per second; and this product multiplied by the coefficient of diminished resistance gives 15850 pounds' resistance due to ship's way.

Girth at midship section in feet....................62·80

This item, when the lines are in hand, is not immediately necessary, although, when such *is* the case, that girth must be measured, in order to lay down the surface of the skin; but in the absence of the lines of the vessel the girth at the midship section becomes a great function of the surface of the skin. The 66 feet, as above, has been actually measured from the body-plan; but where a certain proportion exists between the beam and the draft of water, the girth may be found to a close approximation by multiplying the beam plus twice the draft with a certain coefficient, which coefficient may be found from a Table at the end of this Report, in which the girths at the midship section have all been found from the lines of the ship.

In the case of the 'Atrato,' where the proportion between breadth and draft is as 1 : ·448, the coefficient would be like H.M.S. 'Warrior' and 'Achilles,' or the mean between the two would give ·8; and this multiplied by 40·92 $+2\times 18{\cdot}35=62{\cdot}09$, or ·71 feet shorter than is actually the case. The cause of this is that the 'Warrior' and 'Achilles' both have more rise of floor than the 'Atrato,' and this rise of floor may be judged from the coefficient of fineness of midship section; therefore, by using a little caution in the use of this Table, the girth at the midship section may be found to a very close approximation.

Surface of skin in square feet 17233

This surface has been exactly measured from the lines of the ship; and where this has not been possible, the coefficient of ·77 may be judiciously used from a comparison with other ships, of which the surface of skin has been laid down and calculated, and given at the end of this Report.

Resistance due to skin equal to the surface of the skin multiplied by the square of the speed of the ship, in knots, and the product divided by 100, supposing that the skin of the ship is clean and smooth, or

=27300 pounds skin resistance.

Total resistance equal to 15850+27300=43150 pounds. Horse-power required for ship's way equal to the resistance due to ship's way multiplied by the speed of the ship, in feet per minute, and the product divided by 33000, or

=546 horse-power for ship's way.

Horse-power required for skin-resistance equal to the resistance due to skin multiplied by the speed of the ship, in feet per minute, and the product divided by 33000, or

=940 horse-power for skin-resistance.

Horse-power required for slip equal to the total resistance multiplied by the slip, in feet per minute, and the product divided by 3300, or

=406 horse-power for slip.

Total horse-power required 546+940+406=	1892
Horse-power expended on engines and propeller ..	2207−1892=315
Percentage of total horse-power employed in driving the ship	·24
Percentage of total horse-power employed in driving the skin	·42
Percentage of total horse-power expended on slip ..	·13
Percentage of total horse-power expended on engines and propeller	·14
Consumption of coals per nominal horse-power, per hour	9·9
Consumption of coals per indicated horse-power, per hour	3·6

TABLE A.—Performance of Ships, analyzed by the method

	Anglia.	Admiral.	Cambria.
Proportion of breadth to length : : 1 :	7·21	6·56	7·55
Proportion of draught to breadth : : 1 :	2·90	4·26	2·94
Coefficient of fineness of ⊕ a	·7911	·8916	·8666
Coefficient of fineness of body b	·6148	·5694	·6392
Coefficient of fineness of ends $\frac{b}{a}$	·7771	·6386	·7376
Coefficient of diminished resistance	·0635	·0767	·0576
Coefficient of performance $V^3 \times D^{\frac{2}{3}} \div$ I.H.P.	193·9	203·	162·8
Coefficient of performance $V^3 \times D^{\frac{2}{3}} \div W.$ ...	3176.	7569·	3151·
Coefficient of performance $V^3 \times$ ⊕ $\div$ I.H.P.	496·8	497·	366·
Effective diameter of wheel	22·06	18·5	25·34
Velocity of paddle-wheel, in knots per hour..	17·09	13·75	18·06
Slip, in knots per hour	4·13	1·85	5·85
Slip, per cent..	31.	15·	47.
Slip, in feet per second..............................	7·04	3·15	9·97
Ratio of slip to speed of ship : : 1 :...........	3·13	......	2·08
Area of paddle-race, in square feet............	98·04	......	81·62
Resistance due to area of paddle-race, in lbs.	4858·	......	8113·
Resistance due to length of paddle-race......	20063·	......	16875.
Girth, in feet..	35·34	31·43	35·12
Surface of skin, in square feet..................	5135·	6600·	5347·
Skin resistance, in pounds	8626·	9504·	7972·
Speed of ship, in feet per second	22·11	20·47	20·83
Resistance due to ship's way, in lbs.	5781·	5877·	3490·2
Total resistance, in lbs.	14407·	15381·	11462·
Resistance of paddle-race to resistance of ship : : 1 :	0·71	...... 218·	0·67
Horse-power required for ship's way.........	232·		132·
Horse-power required for skin resistance ...	347·	353·	301·
Horse-power required for slip..................	228·	100·	165·
Horse-power expended on engines and propeller..	8·07	73·	397·35
Percentage of total I.H.P. required for ⊕	28·	40·	13·
Percentage of total I.H.P. required for skin	42·	47·	30·
Percentage of total I.H.P. required for slip	28·	13·	16·
Percentage of total I.H.P. required for engines	1·	9·	40·
Consumption of coals per N.H.P. per hour..	17·	......	15·
Consumption of coals per I.H.P. per hour..	6·8	2.9	5·7

Note 1. The coefficient of diminished resistance has been taken with a length of bow
Note 2. The effective diameter of the wheel as used for analysis has been taken at the
This has been done for the sake of uniformity in the calculations, there being an effective
and 'Telegraph,' in Appendix V. Table I. Report 1859, and of the 'Cambria,' lengthened,
are correct. For example, the diameter of the wheel of the 'Delta' is 26 feet, and the
the effective diameter of wheel is given in the Reports as 25·16 feet. Both are feathering-
for breadth of float 4·5, and the 'Lima' 3 feet.

of Mr. Scott Russell (Merchant Paddle Steamers).

Cambria lengthened.	Callao.	Valparaiso.	Lima.	Lima.	Bogota, single cylinder.
9·06	7·31	7·31	8·36	8·36	8·33
2·81	2·60	2·48	2·61	2·46	2·52
·8213	·8702	·9101	·9752	·8806	·8459
·5942	·5379	·5451	·5463	......	·5530
·7234	·6181	·5989	·6210	......	·6538
·0402	·0515	·0515	·042	·042	·042
215·	224·4	218·7	181·5	......	223·2
3926·	11787·	8657·	7774·	......	12279·
436·9	572·	590·	450·	542·	536·
23·25	23·96	23·90	24·	24·34	23·96
14·59	17·82	17·77	17·85	16·97	17·07
2·36	4·92	6·24	5·85	3·97	4·57
19·	38·	·54	45·	30·	36·
4·02	8·49	10·64	10·64	22·08	7·79
5·18	2·62	1·84	2·22	3·27	2·73
52·96	68·	58·30	65·28	68·	68·
864·	4901·	6600·	6501·	2750·	4126·
4460·	12840·	12144·	13327·	9586·	11263·
35·82	39·96	40·82	42·4	43·44	43·05
6536·	7138·	7292·	8194·	8395·	8287·
9777·	11879·	9694·	11800·	14188·	12948·
20·87	22·06	19·67	20·47	22·12	21·33
3484·9	7017·	6137·	5314·	6411·	5770·
13261·	18896·	15831·	17114·	20599·	18718·
2·97	1·47	1·30	1·28	2·14	1·66
132·	281·	219·	197·	258·	223·
370·	476·	346·	439·	570·	501·
96·9	291·	306·	356·	238·	315·
238·5	2·	−71·	168·	234·	61·
16·	26·7	27·3	16·9	19·8	20·2
44·	45·3	43·2	37·8	43·8	45·5
11·	27·7	38·2	30·6	18·3	28·6
28·	......	−8·7	14·5	18·	5·5
13·3	7·	7·7	9·4	16·8	7·
6·2	2·1	3·08	2·6	5·1	2·

equal to ·55 of the length of the ship.
diameter of the wheel as given in the condensed Tables, minus $\frac{2}{3}$ of the width of the float.
diameter given in the Reports of only the following ships, 'Anglia,' 'Cambria,' 'Scotia,' 'Lima,' and 'Delta' in Table V. Report 1861. It is rather doubtful that these quantities effective diameter is given as 22 feet; the 'Lima' has the same diameter of wheel, but wheels; and there is only a difference of 1·5 in the width of the float, the 'Delta' having

TABLE A (*continued*).—Performance of Ships, analyzed by the

	Scotia.	Telegraph.	Mersey.
Proportion of breadth to length : : 1 :	7·13	8·65	8·48
Proportion of draught to breadth : : 1:	3·05	2·91	2·92
Coefficient of fineness $\oplus$ a	·7918	·8251	·8487
Coefficient of fineness of body b	·5184	·6184	·5815
Coefficient of fineness of ends $\frac{b}{a}$	·6546	·7494	·6852
Coefficient of diminished resistance	190.	·0441	·042
Coefficient of performance $V^3 \times D^{\frac{2}{3}} \div$ I.H.P.	208·6	220·8	256·4
Coefficient of performance $V^3 \times D^{\frac{2}{3}} \div$ W. ...	3491·	3698·	......
Coefficient of performance $V^3 \times \oplus \div$ I.H.P.	510·	446·	563·
Effective diameter of wheel	22·06	24·17	19·05
Velocity of paddle-wheel, in knots per hour.	16·40	18·72	17·85
Slip, in knots per hour...........................	2·79	5·49	4·57
Slip, per cent.	20·	41·	34·
Slip, in feet per second..........................	4·76	9·36	7·79
Ratio of slip to speed of ship : : 1 :	4·87	2·41	2·90
Area of paddle-race, in square feet............	120·	88·4	68·
Resistance due to area of paddle-race, in lbs.	2266·	7744·	4126·
Resistance due to length of paddle-race......	11035·	18663·	11965·
Girth, in feet	35·72	38·	40·40
Surface of skin, in square feet...................	5296·	7133·	7914·
Skin resistance, in pounds	9810·	12486·	13957·
Speed of ship, in feet per second	23·22	22·57	22·66
Resistance due to ship's way, in lbs.	6208·	5047·	5628·
Total resistance, in lbs.	16018·	17533·	19585·
Resistance of paddle-race to resistance of ship : : 1 :	1·45	0·94	1·63
Horse-power required for ship's way	262·	207·	231·
Horse-power required for skin resistance ..	414·	512·	575·
Horse-power required for slip..................	185·	298·	277·
Horse-power expended on engines and propeller	73·	148·	5·
Percentage of total I.H.P. required for $\oplus$ ..	28·	18·	21·2
Percentage of total I.H.P. required for skin	44·4	44·	52·76
Percentage of total I.H.P. required for slip	19·8	25.	25·46
Percentage of total I.H.P. required for engines	7·8	13·	·5
Consumption of coals per N.H.P. per hour.	16·4	17·4	......
Consumption of coals per I.H.P. per hour...	6·6	6·7	......

method of Mr. Scott Russell (Merchant Paddle Steamers).

Delta.	Atrato.	Shannon.	Paramatta.	John Penn.	Leinster and Ulster.
8·73	8·22	7·5	7·53	9·16	9·42
2·35	2·50	2·59	2·61	2·76	2·61
·7565	·8051	·8107	·8484	·7776	·7479
·4943	·4722	·5455	·5743	·4481	·4113
·6534	·5865	·6729	·6769	·5763	·5500
·043	·041	·0585	·058	·049	·0414
346·6	160·6	224·4	227·2	192·1	154·3
......	6840·	8754·	8018·	......	3210·
777·	......	555·	554·	444·	342·
23·	33·5	33·	35·5	12·89	30·34
18·17	18·68	19·43	19·25	15·97	22·09
3·50	4·91	5·54	5·30	0·67	5·81
23·	35·	40.	38·	4·	35·
5·97	8·37	9·45	9·04	1·14	9·91
4·19	2·80	2·50	2·62	25·8	2·76
118·74	132·	130·24	160·08	53·7	150·
4231·	9246·	11630·	13081·	69·27	14731·
17685·	25889·	29191·	34403·	581·43	41246·
52·	58·86	60·77	61·73	25·86	44·5
13271·	15251·	15447.	15658·	3419·	13164·
28560·	28917·	29802.	30471·	8005·	34889·
25·03	23·49	23·70	23·80	26·10	27·78
10775·	10128·	19912·	19914·	3304·	11182·
39335·	39045·	49714·	50385·	11304·	46071·
2·22	1·55	1·89	1·61	7·	1·27
490·	432·	858·	861·	156.	564·
1299·	1235·	1284·	1318·	379·	1762·
598·	594·	854·	828·	23·	727·
−763·	135·	−68·	−67·	240·	1107·
30·	18·	29·	29·	19·5	13·55
79·	51·	43·	45·	47·4	42·36
37·	25·	29·	28·	2·88	17·48
−47·	6·	−2·	−2·	30·	26·61
......	11·2	10·8	12·2	......	30·
......	3·7	2·8	3·1	......	5·3

TABLE B.—Performance of Ships, analyzed by the method

	Tasmanian.	Oneida.	San Carlos.	Guayaquil.
Proportion of breadth to length : : 1 :	8·51	7·66	6·40	6·50
Proportion of draught to breadth : : 1 :	2·04	2·29	2·53	2·56
Coefficient of fineness of midship section a...	·775	·835	·732	·740
Coefficient of fineness of body b	·478	....	·359	·429
Coefficient of fineness of ends $\frac{b}{a}$	·617	....	·490	·579
Coefficient of diminished resistance	·0453	·0561	·0806	·0778
Coefficient of performance $V^3 \times D^{\frac{2}{3}} \div$ I.H.P. .	210·5	....	256·	256·
Coefficient of performance $V^3 \times D^{\frac{2}{3}} \div$ W.......	8680·	....	12208·	15383·
Coefficient of performance $V^3 \times \bigoplus \div$ I.H.P. .	596·29	1175·1	845·5	748·8
Speed of screw, in knots per hour	17·18	13·91	6·31	12·31
Slip, in knots per hour	2·93	1·01	−5·44	0·13
Slip, in feet per second	5·	1·72	−9·2	0·22
Ratio of slip to speed of ship : : 1 :	4·86	12·7	−2·16	92·
Area of screw-race (minus boss), in square feet..	230·20	237·83	81·68	85·37
Area of midship section : area of screw-race : : 1 :	·39	·42	·31	·32
Resistance due to area of screw-race, in lbs...	5755·	701·59	....	4·09
Resistance due to length of screw-race, in lbs.	27969·	8959·	....	376·
Resistance due to ship's way, in lbs.	15447·	15056·	8424·	8475·
Girth, in feet..	61·72	58·4	41·85	41·66
Surface of skin, in square feet..................	15778·	13445·	6187·	6255·
Skin resistance, in lbs.	32039·	22373·	8541·	9007·
Speed of ship, in feet per second	24·31	22·01	20·05	20·47
Total resistance, in lbs............................	40838·	37329·	16965·	17482
Resistance of length of screw : resistance of ship : : 1 :	1·46	4·1	....	46·
Horse-power required for ship's way.........	683·	602·	307·	315·
Horse-power required for skin resistance ...	1416·	895·	311·	335·
Horse-power required for slip	431·	11·	−283·	6·99
Horse-power expended on engines and propeller	270·	−496·	165·	−56·99
Percentage of total I.H.P. required for midship section	24·	59.	61·	52·5
Percentage of total I.H.P. required for skin	50·	88·	62.	55·8
Percentage of total I.H.P. required for slip	15·	1·08	−56.	1·16
Percentage of total I.H.P. required for engines	9·6	−49·	33·	−9·49
Consumption of coals per N.H.P., in lbs. per hour	15·	14·9	9·8	9·3
Consumption of coals per I.H.P., in lbs. per hour	3·	6·6	2·3	1·86

' Mr. Scott Russell (Merchant Screw Steamers).

Undine.	Ceylon.	Colombo.	Pera.	Leonidas.	Penelope.	Midge.	Lancefield.
5·00	6·82	8·40	7·12	6·97	5·82	4·63	6·30
2·46	2·24	2·04	2·30	3·75	3·12	3·16	2·47
·607	·777	·761	·770	·917	·615	·789	·737
·324	·491	·409	·426	·618	·420	·529	·407
·533	·631	·537	·553	·673	·682	·670	·552
·1275	·08576	·0466	·0645	·0817	·1576	·1536	·0829
223·	238·	232·	289·	409·	………	147·	223·5
………	………	9863·	………	13006·	………	5908·	8418·
780·07	677·26	655·78	827·56	975·10	………	467·02	785·
11·29	14·51	13·85	13·46	13·85	15·12	14·20	13·25
2·03	1·17	1·39	0·91	2·15	4·27	3·67	3·25
3·46	1·99	2·37	1·55	3·66	7·28	6·26	5·54
4·55	11·4	8·95	13·7	5·42	2·54	2·87	3·07
46·97	211·42	176·71	179·97	58·07	13·81	16·62	50·26
·30	·36	·33	·30	·28	·43	·41	·32
562·23	537·22	991·34	431·92	775·55	731·79	651·17	1542·47
563·	6124·	8882·	5550·	4043·	1858·	1868·	4735·
912·	25855·	10910·	17226·	6737·	1727·	1807·	3788·
37·84	61·	62·	58·	34·35	16·10	16·12	33·20
343·	14240·	15136·	14080·	5438·	933·	738·	3851.
866·	25340·	23493·	22176·	7444·	1168·	818·	3851.
15·80	22·76	21·26	21·24	19·96	18·51	17·15	17·06
778·	51195·	34408.	39402.	14181·	2895·	2625·	7639.
3·03	8·3	3·8	7·	3·5	1·5	1·4	1·6
141·	1069·	421·	528·	244·	58·	56·	117·
82·	1048·	908·	856·	270·	39·3	25·5	119·4
48·9	185·	148·	111·	94·3	38·3	29·8	76·9
114·9	−262·	51·	−81·	−26·8	−42·	−11·3	−113·
89·	52·	27·	37·	71·	62·	56·	58·
52·	51·	59·	60·	79·	42·	25·5	59·7
31·	9·	9·6	7·8	27·	41·	29·8	38·4
−73	−12.	3·3	−5·7	−78·	−45·	−11·3	−56·
………	………	9·	………	12·04	………	………	5·6
………	………	2·6	………	3·5	3·6	2·8	3·36

TABLE C.—The quantities in the following Table have been calculated in order

shape might have possessed a middlebody, a forebody, and corresponding

of fineness of ends, ·5 L+·5 l''+·19635 B=r L for finding the length of placement. Also a coefficient of diminished resistance has been calculated giving the length of bow as belonging to the speed.

Name of Ship.	Length of ship.	Length of virtual forebody.	Length of forebody as measured from lines.	Length of virtual afterbody.	Length of afterbody as measured from lines.	Length of virtual middlebody.	Length of middle-body as measured from lines.	Displacement of virtual forebody.
	feet.	feet.	feet.	feet.	feet.	feet.	feet.	tons.
Anglia	187·83	91·7472	...	61·1648	...	34·918	...	244·
Admiral	210·	98·604	84·	65·736	72·	45·66	54·	301·44
Cambria	197·75	68·058	...	45·372	...	84·32	...	195·52
„ lengthened	237·	84·7992	...	56·5328	...	95·668	...	242·3
Callao	232·	112·73	...	75·16	...	44·11	...	450·92
Valparaiso	232·	118·87	...	79·25	...	33·88	...	522·72
Lima	251·	121·224	...	80·816	...	48·96	...	522·99
Bogota	250·	110·976	...	73·984	...	65·04	...	478·78
Scotia	192·57	86·238	...	57·492	...	48·84	...	232·68
Telegraph	243·8	79·932	...	53·288	...	110·58	...	256·61
Mersey	254·42	103·188	...	68·792	...	82·44	...	384·74
Delta	308·	136·404	...	90·936	...	80·66	...	779·42
Atrato	336·5	176·592	162·	117·728	163·	42·18	...	1357·2
Shannon	330·13	139·746	...	93·164	...	97·22	...	1209·
Paramatta	329·42	138·132	...	92·088	...	99·20	...	1196·14
John Penn	171·75	91·734	...	61·156	...	18·86	...	129·73
Leinster	327·	169·644	172·	113·086	155·	44·26	...	799·93
Midge	58·75	26·266	28·5	17·484	27·5	15·04	...	14·98
Penelope	74·33	33·018	...	22·01	...	19·30	...	15·56
Lancefield	145·	83·376	62·	55·584	75·	6·04	8·	187·
Macgregor Laird	245·	106·824	...	71·216	...	66·96	...	671·44
Guayaquil	195·	105·384	...	70·256	...	19·36	...	428·55
Maurocordato	221·	87·228	...	58·152	...	75·62	...	553·27
Colombo	313·	182·724	...	122·816	...	8·46	...	1352·1
Pera	300·	159·072	158·	106·048	142·	34·88	...	1345·2
Ceylon	300·	157·5	140·	105·	160·	37·5	...	1309·5
Tasmanian	332·	161·916	164·	107·944	156·	62·14	...	1334·6
Vulcan	160·	90·840	80·	60·560	80·	8·60	...	72·67

1 knot = 1·151

Where the coefficient of fineness of ends is less than ·5, no length of middle-body is possible. This is the case with the 'San Carlos,' where the coefficient of fineness of ends is equal to ·4907, and l'' becomes negative; also with the 'Thunder,' where the coefficient of fineness of ends is equal to ·4264, the smallest coefficient yet obtained. This Table has expressly been prepared to show that

to show how shape might have been economized, and how each vessel of entire afterbody. The formulæ used for the calculations are $r = \frac{D}{L \times \oplus}$ for the coefficient the middle body, and $\cdot 5\ l \oplus + \cdot 5\ l' \oplus + \cdot 19635\ B \oplus + l'' \oplus$ for testing the dis- belonging to the length of bow thus found; further, a column has been added

Displacement of virtual afterbody.	Displacement of virtual middle-body.	Virtual displacement.	Actual displacement.	Coefficient of fineness of virtual afterbody.	Coefficient of diminished resistance belonging to virtual forebody.	Speed of ship.	Length of forebody belonging to speed.	Speed, in statute miles.
tons.	tons.	tons.	tons.			knots.		
189·	185·	618·	620	·5806	·0812	12·96	95·5	15·03
239·36	279·17	819·97	820	·5969	·1053	12·	82·	13·92
159·81	484·47	839·8	840	·6130	·1476	12·2	84·57	14·15
190·89	546·74	979·95	980	·5905	·0951	12·23	85·33	14·18
346·19	352·88	1149·99	1150	·5757	·0661	12·9	95·	14·96
398·81	298·24	1219·97	1220	·5718	·0595	11·53	76·	13·37
399·48	422·45	1344·92	1345	·5734	·0612	12·	82·	13·92
370·08	561·20	1410·06	1410	·5797	·0731	12·5	89·08	14·50
183·63	263·31	679·62	680	·5924	·0980	13·61	105·5	15·78
206·54	709·92	1173·07	1173	·6037	·1241	13·23	100·	15·34
300·42	614·76	1299·92	1300	·5856	·0845	12·288	85·92	14·25
598·72	921·82	2299·96	2300	·5761	·0667	14·67	122·	17·01
1028·32	648·36	3033·88	3034	·5232	·0536	13·771	107·67	15·97
945·6	1683·	3048·03	3840	·5862	·0991	13·898	110·	16·12
946·1	1718·	3860·1	3862	·5932	·01003	13·906	110·	16·13
96·90	53·34	279·97	280	·5601	·0417	15·3	131·5	17·74
597·90	417·3	1815·13	1815	·5659	·0425	16·28	148·	18·88
12·83	17·18	44·99	45	·6421	·2333	10·53	63·5	12·21
12·76	18·19	46·51	465	·6148	·1491	10·85	67·	12·58
144·91	27·09	359·	359	·5811	·0761	9·6	53·	11·13
521·69	841·78	2034·91	2035	·5827	·0788	9·5	51·20	11·02
304·70	143·81	839·92	840	·5838	·0810	12·	82·	13·92
450·42	961·4	1965·09	1963	·6105	·1409	11·19	71·	12·98
1017·03	125·20	2494·	2487	·5595	·0415	12·46	88·5	14·45
1036·60	589·97	2971·77	2972	·5779	·0699	12·556	89·5	14·56
1006·86	623·57	2939·93	2940	·5766	·0677	13·34	101·16	15·47
1016·01	1024·4	3375·01	3375	·5709	·0580	14·25	115·92	16·53
53·56	13·76	139·99	140	·5527	·0321	14·5	119·5	16·82

statute miles.

even the virtual length of forebody, answering to the given displacement, is in most cases even longer than the length of forebody as required for speed; and that, therefore, in very few cases the ratio in which the actual length of afterbody is less than least proper length as required for speed can be calculated.

Table D.—Girths of Midship section as measured from the Lines of the Ships.

Name.	Girth, in feet.	Draft = breadth, multiplied by coefficient.	B+2d multiplied by coefficient.	Coefficient of fineness of midship Section.	Paddle or screw.
Scotia	80·	·469	·879	·9644	Paddle.
Hibernia	66·	·529	·868	·9225	Screw.
Guienne	55·5	·421	·816	·8338	Screw.
Tigre	59·	·487	·796	·7514	Screw.
Delta	52·	·438	·800	·7565	Paddle.
Pera	58·	·440	·743	·7718	Screw.
Bremen	61·5	·436	·798	......	Screw.
Nubia	57·5	·469	·756	......	Screw.
Ceylon	61·	·414	·783	·7780	Screw.
Australasian	71·	·5	·842	·9038	Screw.
Douro	66·	·476	·846	·9078	Screw.
Leinster	49·5	·357	·825	·7479	Paddle.
Undine	32·84	·407	·808	·6072	Screw.
Great Eastern	116·	·342	·843	·8614	Both.
Great Britain	72·	·381	·782	·8281	Screw.
European	38·	·440	·808	·8399	Screw.
Hope	48·	·242	·923	......	Paddle.
Iona	30·	·180	·941	......	Paddle.
Queen of the Orwell	22·	·237	·846	......	Paddle.
Persia	72·	·444	·847	......	Paddle.
H. M. Rattler	44·	·344	·814	·7025	Screw.
Fire Queen	22·67	·282	·743	·7903	Screw.
H. M. Victoria and Albert	52·	·335	·778	......	Paddle.
H. M. Warrior	86·	·448	·788	·8c64	Screw.
H. M. Achilles	89·	·429	·824	·8651	Screw.

It is evident that great judgment must be used in using these Tables, an to select the same class of steamer.

Example of Analysis of the Royal Mail Paddle Steamer 'Atraio,' according to Professor Rankine's method.

1. L, length on load water-line, in feet.......... 336·5

2. G, mean immersed girth, in feet, as calculated from the girths at twenty-five equidistant cross-sections by Simpson's multipliers .. 52

The girths are measured for the purpose of calculating an *integral*, viz. $\int G'dx$, where G′ is any girth, and dx an element of the length; the use of Simpson's multipliers gives a more accurate value of the true mean girth, than is given by merely adding together the girths and dividing by their number. In practice, however, where the cross-sections are very numerous, there is scarcely any difference between the ordinary arithmetical mean and the mean as found by Simpson's multipliers. Where there are few cross-sections, the use of Simpson's multipliers becomes necessary.

3. $\oplus$, area of immersed midship section, in square feet......653.

4. m, ratio in which virtual length of afterbody is less than least proper length for speed by the wave theory.

5. m', ratio in which virtual length of forebody is less than length of solitary wave for speed by the wave theory.

The virtual lengths here referred to are those deduced from the displacement and dimensions by Mr. Scott Russell's method; that is to say, the lengths of wave-line afterbody and forebody, which would give the same displacement.

These two quantities are to be calculated only when less than 1; for when equal to or greater than 1, they have no influence on the results.

6. γ^2, mean of squares of sines of angles of obliquity of stream-lines of afterbody at their points of inflexion .... ·0611.

Calculated thus:—

Water-lines.	Sines of obliquity.	Squares of sines.
1	·0871	·0075
2	·1391	·0193
3	·1736	·0301
4	·2079	·0432
5	·2588	·0669
6	·3090	·0954
LWL	·4067	·1654
	Sum	·4278
	Mean	$\cdot 0611 = \gamma^2$

7. β^2, mean of squares, and β^4, mean of fourth powers, of sines of angles of obliquity of streamlines of forebody at their points of inflexion.

Calculated thus:—

Water-lines.		Sines of obliquity.		Squares of sines.		4th power of sines.
1	....	·0871	....	·0075	....	·000057
2	....	·1391	....	·0193	....	·000374
3	....	·1736	....	·0301	....	·000908
4	....	·2079	....	·0432	....	·001868
5	....	·2419	....	·0585	....	·003424
6	....	·2588	....	·0669	....	·004486
LWL	....	·2923	....	·0854	....	·007299
			Sums	·3109	....	·018416
			Means	$·0444=\beta^2$	....	$·002631=\beta^4$

6 and 7 should be measured upon normal lines if possible. In the present case the angles have been measured upon water-lines, as shown in the half-breadth plan.

8. A, augmented surface in square feet $=LG\ (1+4\beta^2+\beta^4)$,

or	Log L	=	2·5269851
	Log G	=	1·7160033
	Log $1+4\beta^2+\beta^4$	=	0·0719556
			4·3149440
	Nat¹ nʳ	=	20651·=augmented surface.

The factor $1+4\beta^2+\beta^4$ is called the "coefficient of augmentation."

9. A′, correction of augmented surface, in square feet, or $560\gamma^2 \oplus \sqrt{1-m^2}$. This quantity disappears in the present case; because $m > 1$; and it has to be calculated for those vessels only in which the afterbody is too short for the speed.

10. Coefficient of propulsion $\dfrac{(A+A')\times V^3}{\text{I.H.P.}}=13211.$

The meaning of the term "Augmented Surface" is explained by the following extract from the 'Transactions of the Institution of Naval Architects,' vol. v. 1864:—"The resistance to the motion of the ship, due to the production of frictional eddies, by a given portion of her skin, is the product of the following factors:—

"I. The area of the portion of the skin in question.

"II. The *cube* of the ratio which the velocity of gliding of the particles of water over that area bears to the speed of the ship, being a quantity depending on the figure of the ship and the position of the part of her skin under consideration.

"III. The height due to the ship's speed, that is (in feet),

$$\frac{(\text{speed in feet per second})^2}{64\cdot4},\ \text{or}\ \frac{(\text{speed in knots})^2}{22\cdot6}.$$

"IV. The heaviness (or weight of an unit of volume) of the water (64 lbs. per cubic foot of sea-water).

"V. A factor called the coefficient of friction, depending on the material with which the ship's skin is coated, and its condition as to roughness or smoothness.

"The sum of the products of the factors I. and II. for the whole skin of the ship is called her *augmented surface*; and the eddy-resistance of the whole ship may therefore be expressed as the product of the augumented surface by the factors III., IV., and V., above mentioned."

The "coefficient of propulsion" may be defined as the number of square feet of augmented surface which are driven at one knot by one indicated horse-power.

TABLE E.—Performance of Ships,

	H.M.S. Lily*.	H.M.S. Eclipse.	H.M.S. Dwarf.	H.M.S. Impérieuse.	H.M.S. Warrior.
Displacement in tons of 35 cubic ft.	634·	625·	98·	3044·	8997·
Length on load-water-line, in feet	185·	185·	126·5	212·	380·
Mean immersed girth, in feet......	31·80	30·	17·	61·24	76·3
Area of immersed midship section, in square feet...............	200·	198·	44·	688·	1230·
Speed of ship, in knots per hour...	10·	11·	10·537	10·111	14·356
Indicated horse-power...............	474·1	838·4	216·	1199·8	5469·
Ratio in which virtual length of afterbody is less than least proper length as required for speed by wave theory	...	...	...	...	...
Ratio in which virtual length of forebody is less than least proper length as required for speed by wave theory	...	...	...	...	...
Mean of squares of sines of angles of obliquity of stream lines of afterbody at their points of inflexion	·0878	·0878	·0240	·2534	·2586
Mean of squares of sines of angles of obliquity of stream lines of forebody at their points of inflexion	·04318	·04318	·0199	·2721	·0528
Coefficient of augmentation.........	1·1749	1·1749	1·0802	2·1968	1·275
Augmented surface, in square feet.	6911·9	6520·	2323·	28562·	36976·
Correction of augmented surface...		...	...	...	...
Coefficient of propulsion	14579·	10351·	12581·	24607·	20950·
Speed^3 × Displacement $\frac{2}{3}$ ÷ I.H.P.	155·7	116·1	115·13	181·	234·

In the above Table five wooden copper-sheathed ships have been inserted, viz. the ‘Lily,’ ‘Eclipse,’ ‘Imperieuse,’ ‘Vectis,’ and ‘Victoria and Albert.’

* Half-boiler power.

analyzed by Professor Rankine's method.

H.M.S. Achilles.	Undine.	Leinster.	Atrato.	Tasmanian.	Midge.	Great Eastern.	Lancefield.
...	294·	1675·	3979·	3760·	45·	20250·	359·
380·	125·	327·	336·5	332·	58·75	680·	145·
77·4·	30·9	40·18	52·	52·52	11·18	80.	27·64
1322.	154·33	330.	653·	666.	40·	1678·	157·
14·322	9·26	16·28	11·22	10·67	10·53	14·28	about 9·6
5724·	157·09	4160·	2207·98	1442·19	100·	8256·	about 200·
...	...	...	...	...	·63		
...	...	...	...	...	·46		
·2637	·0653	·0302	·0611	·0382	·0884	·0318	
·0662	·0295	·0142	·0444	·0363	·0851	·0225	
1·2701	1·1191	1·057	1·1801	1·1468	1·349	1·0905	1·165
37366.	4322·5	13887·77	20651·	19541·	886·05	59323·	4450·
...	...	...	...	...	1538.		
19172·	21848·	14404.	13211·	16461·	28303·	20923.	about 19700·
...	223·	154·3	160·6	210·5	147·	263.	223·5

TABLE E (*continued*).—Performance of Ships,

	Vectis.	Lyons and Orleans.	Scotia.	Jason* (screw).	Sea-King* (screw).	Admiral (paddle).
Displacement in tons of 35 feet	...	...	...	1730·	1830·	825·
Length on load-water-line, in feet	227·5	189·75	362·42	208·	220·	210·
Mean immersed girth, in feet	33·11	20·82	67·5	43·43	41·92	31·43
Area of immersed mid-ship section, in square feet............	28·4	110·	950·	404·	376·	...
Speed of ship, in knots per hour	15·	15·2	13·9	10·6	10·82	12·
Indicated horse-power...	1300	1108·	4950·	875·	800·	744·
Ratio in which virtual length of afterbody is less than least proper length as required for speed by wave theory*	...	·81	...	...	...	...
Ratio in which virtual length of forebody is less than least proper length as required for speed by wave theory*	...	·81	...	...	...	...
Mean of squares of sines of angles of obliquity of stream-lines of afterbody at their points of inflexion	·0765	·0312	...	...	...	...
Mean of squares of sines of angles of obliquity of stream-lines of forebody at their points of inflexion	·02744	·0105	·0441	...	...	...
Coefficient of augmentation..................	1·1106	1·0423	1·1786	1·63	1·336	1·297
Augmented surface in square feet	8365·	4116·	28405·	14758·	12530·	8560·
Correction of augmented surface......	...	1134·	...	...	...	...
Coefficient of propulsion	22644·	16543·	15411·	20088·	19844·	19881·
$\text{Speed}^3 \times \text{Disp.}^{\frac{2}{3}} \div$ I.H.P.	...	...	...	196·	237·	206·

* Information given by

analyzed by Professor Rankine's method.

Black Swan (screw).	H.M.S. Fairy (screw).	Vulcan (paddle).	Queen of the Orwell (paddle).	H.M.S. Victoria and Albert (paddle).	Neptune (paddle).	Colombo (screw).	Shannon (paddle).
1670·	168·	140·	155·	1980·	212·	2487·	3840·
244·	144·	160·	166·	300·	198·	313·	330·
40·	19·	14·75	16·56	40·	...	44·5	54·7
...	...	...	61·	...	...	518·	606·
12·	13·324	14·5	15·065	16·827	17·43	12·46	13·898
970·	364·	412·	655½·	2980·	1316·	1528·	2928·5
...	...	...	0·71	...	0·7 nearly.		
...	...	...	0·67	...	0·7 nearly.		
...	...	...	...	...	...	0·0723	0·0686
...	...	...	...	...	...	0·0413	0·0499
1·2	1·123	1·0715	1·0704	1·102	...	1·168	1·203
1760·	3072·	2572·	2982·	13224·	3965·	16268·	21716·
...	...	...	967·	...	1127·		
0950·	19960·	19034·	20500·	21143·	20500·	20595·	19907·
251·	198·	203·5	151·	252·6	143·	228·	224·6

Messrs. A. and J. Inglis.

On the Results of Spectrum Analysis as applied to the Heavenly Bodies; a Discourse delivered before the British Association at Nottingham, on August 24, 1866. By WILLIAM HUGGINS, *F.R.S., Hon. Sec. to the Royal Astronomical Society.*

(Abstract*.)

[Plates III. IV.]

THE speaker commenced with a few preliminary remarks on the importance to Astronomy of the analysis of light by the prism. The researches of Kirchhoff have placed in the hands of the astronomer a method of analysis which is specially suitable for the examination of the heavenly bodies. So unexpected and important are the results of the application of spectrum analysis to the objects in the heavens, that this method of observation may be said to have created a new and distinct branch of astronomical science.

Physical Astronomy, the imperishable and ever-growing monument to the memory of Newton, may be described as the extension of terrestrial dynamics to the heavens. It seeks to explain the *movements* of the celestial bodies on the supposition of the universality of an attractive force similar to that which exists upon the earth.

The new branch of astronomical science which spectrum analysis may be said to have founded, has for its object to extend the laws of terrestrial physics to the other phenomena of the heavenly bodies, and it rests upon the now established fact that matter of a nature common to that of the earth, and subject to laws similar to those which prevail upon the earth, exists throughout the stellar universe.

The peculiar importance of Kirchhoff's discovery to *astronomy* becomes obvious, if we consider the position in which we stand to the heavenly bodies. Gravitation and the laws of our being do not permit us to leave the earth, it is therefore by means of *light alone* that we can obtain any knowledge of the grand array of worlds which surround us in cosmical space. The star-lit heavens is the only chart of the universe we have, and in this luminous chart each twinkling point is the sign of an immensely vast, though distant region of activity.

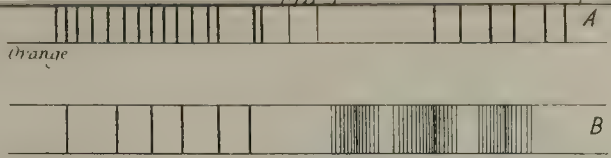
Hitherto the light from the heavenly bodies, even when collected by the largest telescopes, has conveyed to us but very meagre information, and in some cases only of their form, their size, and their colour. The discovery of Kirchhoff enables us to interpret symbols and indications hidden within the light itself, which furnish trustworthy information of the chemical, and also to some extent of the physical condition of the excessively remote bodies from which the light has emanated.

Newton found that when white light is made to pass through a prism of glass it is decomposed into the beautiful colours which are seen in the rainbow. These colours, when they are in this way separated from each other, form the *Spectrum* of the light.

About a century later Wollaston and Fraunhofer made the discovery that when the light of the sun is decomposed by a prism, the rainbow colours which form its spectrum are not continuous, but are interrupted by a large number of dark lines. These lines of darkness are the symbols which indicate the chemical constitution of the sun. It was not until recently, in the year 1859, that Kirchhoff taught us the true nature of these lines. He himself immediately applied his method of interpretation to the dark lines of the

* Communicated by the lecturer in conformity with a Resolution of the General Committee at Norwich, 1868.

Fig. 1.



β Cygni

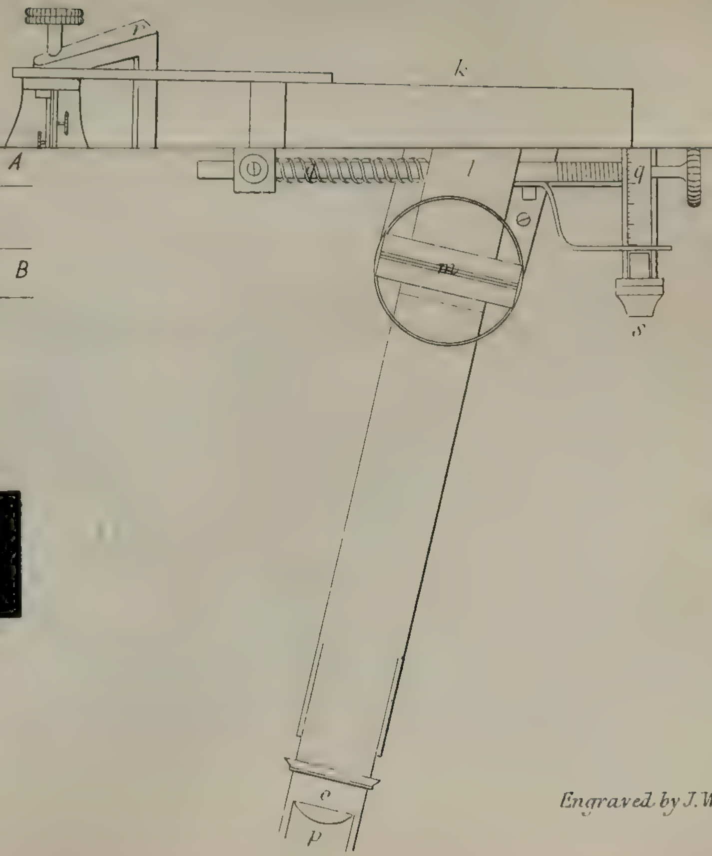
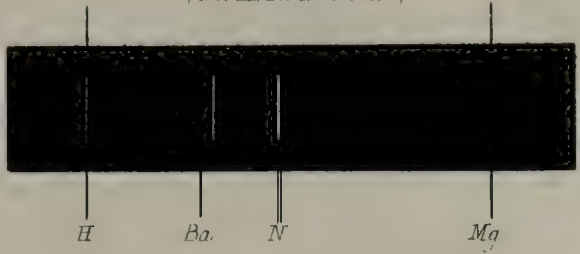
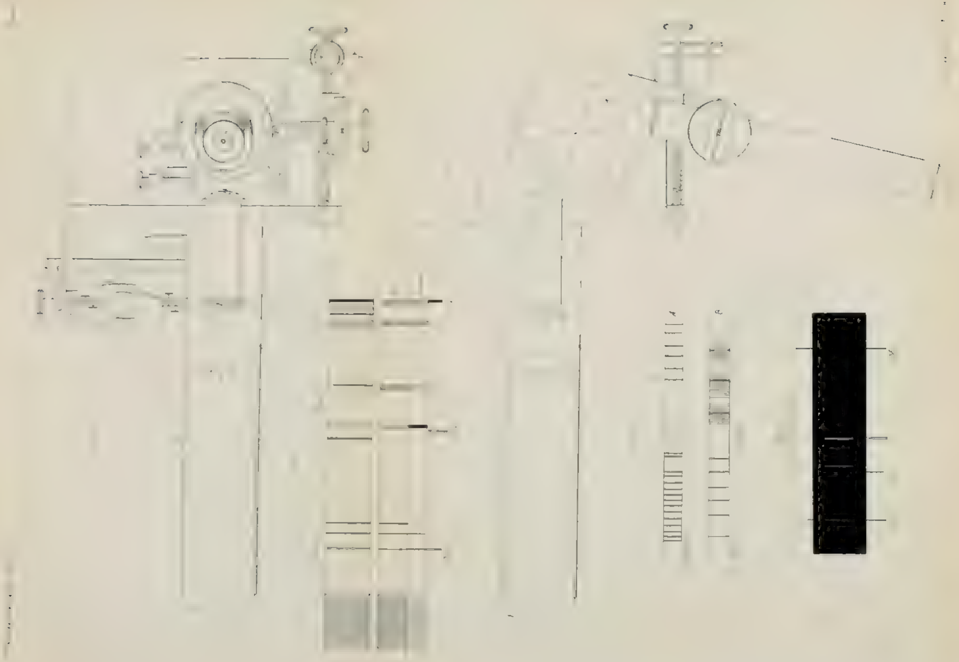


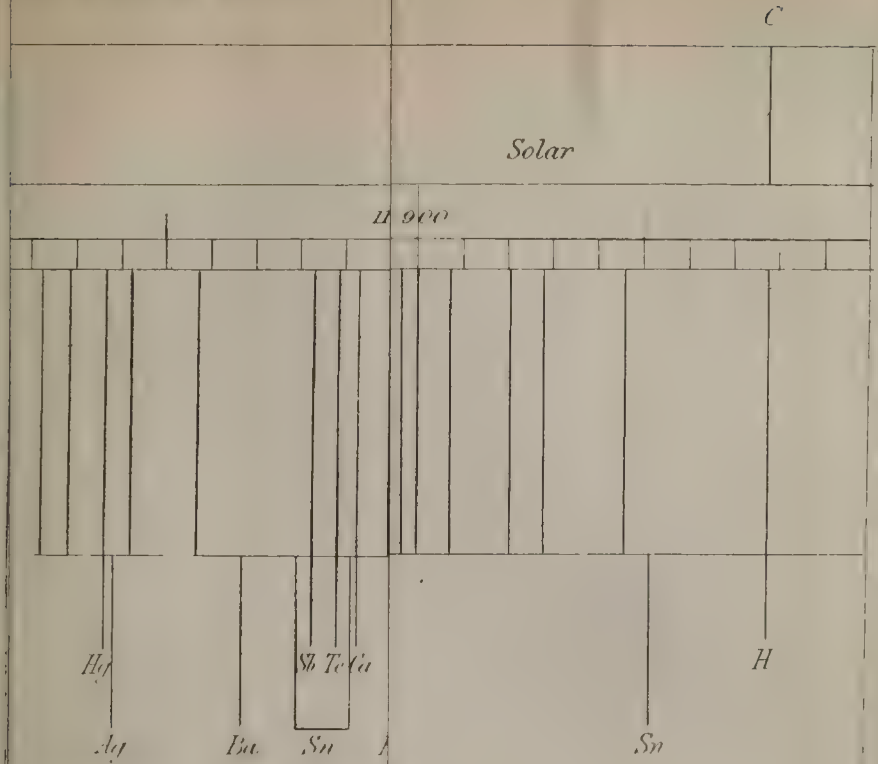
Fig. 5.
(37. H. IV. Draconis)



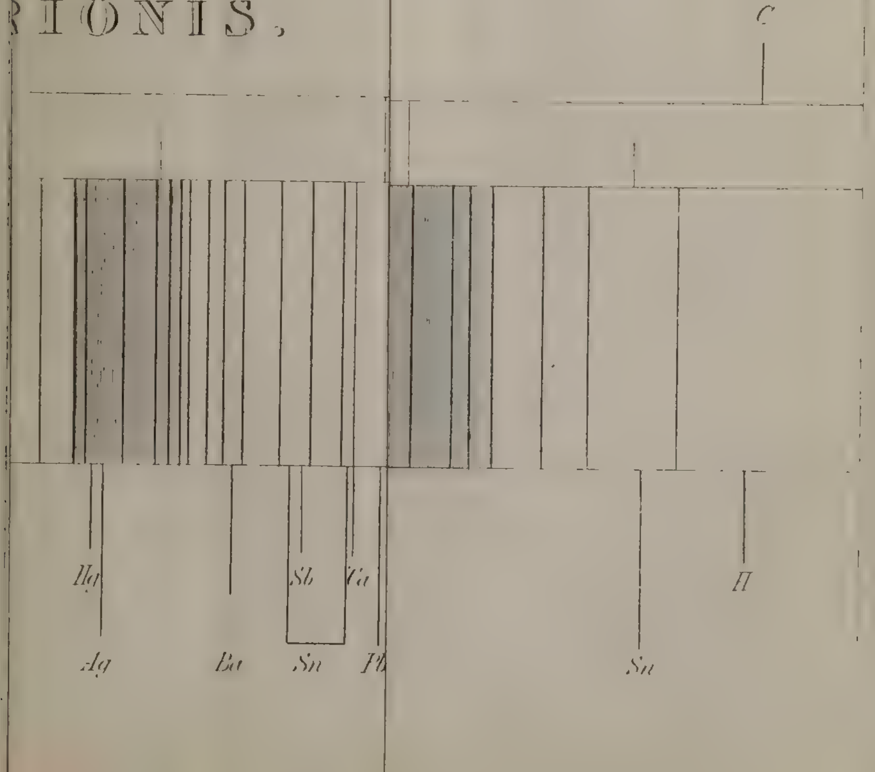
Engraved by J. W. Lowry



EBARAN.



RIONIS.



ALDEBARAN.

α ORIONIS

solar spectrum, and was rewarded by the discovery that several of the chemical elements which exist upon the earth, are present in the solar atmosphere.

The speaker stated that it was his intention on this occasion to bring before the Association the results of the extension of this method of analysis by the prism to the heavenly bodies other than the sun. These researches have been carried on in his Observatory during the last four years. In respect of a large part of these investigations, viz. those of the moon, the planets, and fixed stars, he has had the great pleasure of working conjointly with the very distinguished chemist and philosopher Dr. W. Allen Miller, Treas. R.S.

The speaker then referred to the principles of spectrum analysis upon which their interpretation of the phenomena observed in the spectra of the heavenly bodies was based, stating that spectra may be arranged under three orders.

1. The special character which distinguishes spectra of the *first order* consists in that the continuity of the coloured band is unbroken either by dark or bright lines. We learn from such a spectrum that the light has been emitted by an opake body, and almost certainly by matter in the solid or liquid state. A spectrum of this order gives to us no knowledge of the chemical nature of the incandescent body from which light comes.

2. Spectra of the *second order* are very different. These consist of coloured lines of light separated from each other. From such a spectrum we may learn much. It informs us that the luminous matter from which the light has come is in the *state of gas*. It is only when a luminous body is free from the molecular trammels of solidity and liquidity that it can exhibit its own peculiar power of emitting some coloured rays alone. Hence substances *when in a state of gas*, may be distinguished from each other by their spectra. Each element, and every compound body that can become luminous in the gaseous state without suffering decomposition, is distinguished by a group of lines peculiar to itself. It is obvious that if the groups of lines characterizing the different terrestrial substances be known, a comparison of these, as standard spectra, with the spectrum of light from an unknown source, will show whether any of these terrestrial substances exist in the source of the light.

3. The *third order* consists of the spectra of incandescent solid or liquid bodies, in which the continuity of the coloured light is broken by dark lines. These dark spaces are not produced by the source of the light. They tell of vapours through which the light has passed on its way, and which have robbed the light by absorption of certain definite colours or rates of vibration; such spectra are formed by the light of the sun and stars.

Kirchhoff has shown that if the vapours of terrestrial substances come between the eye and an incandescent body, they cause groups of dark lines, and further, that the *group of dark lines* produced by each vapour is identical in number and in position in the spectrum with the *group of bright lines* of which its light consists when the vapour is luminous.

It is evident that Kirchhoff by this discovery furnished us with the means of interpreting the dark lines of the solar spectrum. For this purpose it is necessary to compare the bright lines in the spectra of the light of terrestrial substances when *in the state of gas* with the dark lines in the solar spectrum. When a group of bright lines coincides with a similar group of dark lines, we know that the terrestrial substance producing the bright lines is present in the atmosphere of the sun. For it is this substance, and this substance alone, which by its own peculiar power of absorption can

produce that particular group of dark lines. In this way Kirchhoff discovered the presence of several terrestrial elements in the solar atmosphere.

Methods of Observation.

The speaker then described the special methods of observation by which, in their investigations, they applied these principles of spectrum analysis to the light of the heavenly bodies. He stated that several circumstances unite to make these observations very difficult and very irksome. In our climate, on few nights only, even of those in which the stars shine brilliantly to the naked eye, is the air sufficiently steady for these extremely delicate observations. Further, the light of the stars is feeble. This difficulty has been met, in some measure, by the employment of a large telescope. The light of a star falling upon the surface of its object-glass of eight inches aperture is gathered up and concentrated at the focus into a minute and brilliant point of light.

Another inconvenience arises from the apparent movement of the stars, caused by the rotation of the earth, which carries the astronomer and his instruments with it. This movement was counteracted by a movement given by clockwork to the telescope in the opposite direction. In practice, however, it is not easy to retain the image of a star for any length of time exactly within the jaws of a slit only the $\frac{1}{300}$ inch apart. By patient perseverance these difficulties have been overcome, and satisfactory results obtained. They considered that the trustworthiness of their results must rest chiefly upon *direct and simultaneous comparisons* of terrestrial spectra with those of celestial objects. For this purpose the apparatus which is represented in fig. 1, and fig. 2, Plate III., was contrived.

By the outer tube *c* the instrument is adapted to the eye-end of the telescope, and is carried round with it by the clock motion. Within this outer tube a second tube *b* slides carrying a cylindrical lens, *a*. This lens is for the purpose of elongating the round point-like image of the star into a short line of light, which is made to fall exactly within the jaws of a narrow slit, *d*. Behind the slit, an achromatic lens, *g* (and at the distance of its own focal length), causes the pencils to emerge parallel. They then pass into two prisms, *h*, of dense flint glass. The spectrum which results from the decomposition of the light by the prisms is viewed through a small achromatic telescope, *l*. This telescope is provided with a micrometer screw, *q*, by which the lines of the spectra may be measured.

The light of the terrestrial substances which are to be compared with the stellar spectra is admitted into the instrument in the following manner:—

Over one half of the slit is fixed a small prism, *e*, which receives the light reflected into it by the moveable mirror *f* placed above the tube. The mirror faces a clamp of ebonite, *r*, provided with forceps to contain fragments of the metals employed. These metals are rendered luminous in the state of gas by the intense heat of the sparks from a powerful induction coil. The light from the spark reflected into the instrument by means of the mirror and the little prism passes on to the prisms in company with that from the star. In the small telescope the two spectra are viewed in juxtaposition, so that the coincidence and relative positions of the bright lines in the spectrum of the spark with dark lines in the spectrum of star can be accurately determined.

Moon and Planets.

The speaker referred in a few words only to the spectra of the moon and planets. These objects, unlike the stars and nebulæ, are not *original* sources

of light. Since they shine by reflecting the sun's light, their spectra resemble the solar spectrum, and the only indications in their spectra which may become sources of knowledge to us are confined to any modifications which the solar light may have suffered either in the atmospheres of the planets, or by reflection at their surfaces.

Moon.—On the moon the results of their observations have been negative. The spectra of the various parts of the moon's surface, when examined under different conditions of illumination, showed no indication of an atmosphere about the moon. The speaker also watched the spectrum of a star, as the dark edge of the moon advanced towards the star, and then occulted it. No signs of a lunar atmosphere presented themselves.

Jupiter.—In the spectrum of Jupiter, lines are seen which indicate the existence of an absorptive atmosphere about this planet. In fig. 3, Plate III. these lines are presented as they appeared when viewed simultaneously with the spectrum of the sky which, at the time of observation reflected the light of the setting sun. One strong band corresponds with some terrestrial atmospheric lines, and probably indicates the presence of vapours similar to those which are about the earth. Another band has no counterpart amongst the lines of absorption of our atmosphere, and tells us of some gas or vapour which does not exist in the earth's atmosphere.

Saturn.—The spectrum of Saturn is feeble, but lines similar to those which distinguish the spectrum of Jupiter were detected. These lines are less strongly marked in the ansæ of the rings, and show that the absorptive power of the atmosphere about the rings is less than that of the atmosphere which surrounds the ball. Janssen has quite recently found that several of the atmospheric lines are produced by aqueous vapour. It appears to be very probable that aqueous vapour exists in the atmospheres of Jupiter and Saturn.

Mars.—On one occasion some remarkable groups of lines were seen in the more refrangible part of the spectrum of Mars. These may be connected with the red colour which distinguishes this planet.

Venus.—Though the spectrum of Venus is brilliant and the lines of Fraunhofer were well seen, no additional lines affording evidence of an atmosphere about Venus were detected. The absence of lines may be due to the circumstance that the light is probably reflected, not from the planetary surface, but from clouds at some elevation above it. The light which reaches us in this way by reflection from clouds would not have been exposed to the absorbent action of the lower and denser strata of the planet's atmosphere.

The Fixed Stars.

The fixed stars, though immensely more remote, and less conspicuous in brightness than the moon and planets, yet because they *are original sources of light*, furnish us with fuller indications of their nature. The telescope was appealed to in vain, for in the largest instruments the stars remain diskless—brilliant points merely.

The stars have, indeed, been represented as suns, each upholding a dependent family of planets. This opinion rested *upon a possible analogy alone*. It was not more than a speculation. We possessed no certain knowledge *from observation* of the true nature of those remote points of light. This long and earnestly coveted information is at last furnished by spectrum analysis. We are now able to read in the light of each star some indications of its nature. The speaker referred to two bright stars which had been examined with great care. The spectra of these stars are represented in Plate IV.

The upper one represents the spectrum of Aldebaran, and the other that of Betelgeux, the star marked α in the constellation of Orion.

The positions of all these dark lines, about eighty in each star, were determined by careful and repeated measures. These measured lines form but a small part of the numerous fine lines which may be seen in the spectra of these stars.

Beneath the spectrum of each star are arranged the bright lines of the metals which have been compared with it. These terrestrial spectra appeared in the instrument, as they are represented in the diagram, in *juxtaposition* with the spectrum of the star. By such an arrangement it is possible to determine with great accuracy whether or not any of these bright lines actually coincide with any of the dark ones.

The results on these stars are given in the following Table:—

ELEMENTS COMPARED WITH ALDEBARAN.

Coincident.

1. Hydrogen with lines C and F.
2. Sodium with double line D.
3. Magnesium with triple line *b*.
4. Calcium with four lines.
5. Iron with four lines and E.
6. Bismuth with four lines.
7. Tellurium with four lines.
8. Antimony with three lines.
9. Mercury with four lines.

Not coincident.

Nitrogen	compared	with	three lines.
Cobalt	,,	,,	two lines.
Tin	,,	,,	five lines.
Lead	,,	,,	two lines.
Cadmium	,,	,,	three lines.
Barium	,,	,,	two lines.
Lithium	,,	,,	one line.

ELEMENTS COMPARED WITH BETELGEUX.

Coincident.

1. Sodium with double line D.
2. Magnesium with triple line *b*.
3. Calcium with four lines.
4. Iron with three lines and E.
5. Bismuth with four lines.
6. Thallium (?).

Not coincident.

Hydrogen	compared	with	C and F.
Nitrogen	,,	,,	three lines.
Tin	,,	,,	five lines.
Lead	,,	,,	two lines.
Gold (?).			
Cadmium	,,	,,	three lines.
Silver	,,	,,	two lines.
Mercury	,,	,,	four lines.
Barium	,,	,,	two lines.
Lithium	,,	,,	one line.

Now, in reference to all these elements, the evidence does not rest upon the coincidence of *one* line, which would be worth but little, but upon the coincidence of a group of two, three, or four lines, occurring in different parts of the spectrum. Other corresponding lines are probably also present, but the faintness of the star's light limited the comparisons to the stronger lines of each element.

What elements do the numerous other lines in the star represent? Some of them are probably due to the vapours of other *terrestrial* elements which we have not yet compared with these stars. But may not some of these lines be the signs of primary forms of matter unknown upon the earth? Elements new to us may here show themselves, which form large and important series of compounds, and therefore give a special character to the physical conditions of these remote systems. In a similar manner the spectra of terrestrial substances have been compared with several other stars.

β Pegasi contains sodium, magnesium, and perhaps barium.
Sirius contains sodium, magnesium, iron, and hydrogen.
α Lyræ (Vega) contains sodium, magnesium, iron.
Pollux contains sodium, magnesium, iron.

About sixty other stars have been examined, all of which appear to have some elements in common with the sun and earth, but the selective grouping of the elements in each star is probably peculiar and unique.

A few stars, however, stand out from the rest, and appear to be characterized by a peculiarity of great significance. These stars are represented by Betelgeux and β Pegasi. The general grouping of the lines of absorption in these stars is peculiar, but the remarkable and exceptional feature of their spectra is the absence of the two lines which indicate hydrogen, one line in the red, and the other in the green. These lines correspond to Fraunhofer's C and F. The absence of these lines in some stars shows that the lines C and F are not due to the aqueous vapour of our atmosphere.

It is worthy of consideration that the terrestrial elements which appear most widely diffused through the host of stars are precisely some of those which are essential to life, such as it exists upon the earth, namely, hydrogen, sodium, magnesium, and iron. Besides, hydrogen, sodium, and magnesium represent the ocean, which is an essential part of a world constituted like the earth.

We learn from these observations that *in plan of structure* the stars, or at least the brightest of them, resemble the sun. Their light, like that of the sun, emanates from intensely white-hot matter, and passes through an atmosphere of absorbent vapours. With this unity of general plan of structure, there exists a great diversity amongst the individual stars. Star differs from star in chemical constitution. May we not believe that the individual peculiarities of each star are essentially connected with the special purpose which it subserves, and with the living beings which may inhabit the planetary worlds by which it may possibly be surrounded.

When they had obtained this new information respecting the *true nature* of the stars, their attention was directed to the phenomena which specially distinguish some of the stars.

Colours of the Stars.

The colour of the light of the stars which are bright to the naked eye is always some tint of *red, orange,* or *yellow.* When, however, a telescope is employed, in close companionship with many of these ruddy and orange stars, other fainter stars become visible, the colour of which may be *blue,* or *green,* or *purple.*

Now it appeared to be probable that the origin of these differences of colour among the stars may be indicated by their spectra. It was obvious that if the dark lines of absorption were more numerous or stronger in some part of the spectrum, then those colours would be subdued in power, relatively to the colour in which few lines only occur. These latter colours remaining strong would predominate, and give to the light, originally white, their own tints.

This supposition was confirmed by observations of the spectra of several white and coloured stars. The grouping of the dark lines in the stars Sirius, α Lyræ, α Herculis, β Cygni, and some others which were examined for this purpose, was such as to account for the difference of colour exhibited by their light. The spectra of the two stars forming β Cygni are represented in fig. 4, Plate III.

It appears, therefore, that the colours of the stars are in general produced by the vapours existing in their atmosphere. The chemical constitution of a star's atmosphere will depend upon the elements existing in the star and upon its temperature.

Variable Stars.

The brightness of many of the stars is found to be variable. From night to night, from month to month, or from season to season, their light may be

observed to be continually changing, at one time increasing, at another time diminishing. The careful study of these variable stars by numerous observers has shown that their continual changes do not take place in an uncertain or irregular manner. The greater part of these remarkable objects wax and wane in accordance with a fixed law of periodic variation which is peculiar to each.

The speaker stated that he had been seeking for some time to throw light upon this strange phenomenon by means of observation of their spectra. If in any case the periodic variation of brightness is associated with *physical changes* occurring in the star, we might obtain some information by means of the prism. Again, if the diminution in brightness of a star should be caused by the interposition of a dark body, then in that case, if the dark body be surrounded with an atmosphere, its presence might possibly be revealed to us by the appearance of additional lines of absorption in the spectrum of the star when at its minimum. Some small changes have been suspected, but further observations are required before any conclusion can be with certainty deduced from them.

Temporary Stars.

With the variable stars modern opinion would associate the remarkable phenomena of the so-called *new stars* which occasionally, but at long intervals, have suddenly appeared in the sky. But in no case has a permanently bright star been added to the heavens. The splendour of all these objects was temporary only, though whether they died out or still exist as extremely faint stars is uncertain. In the case of the two modern temporary stars, the one seen by Mr. Hind in 1845, and the bright star recently observed in Corona, though they have lost their ephemeral glory, they still continue as stars of the 10th and 11th magnitude.

The old theories respecting these strange objects must be rejected. We cannot believe, with Tycho Brahe, that objects so ephemeral are *new creations*, nor with Riccioli, that they are stars brilliant on one side only, which have been suddenly turned round by the Deity. The theory that they have suddenly darted, towards us with a velocity greater than that of light, from a region of remote invisibility, will not now find supporters.

On the 12th of May last a star of the 2nd magnitude suddenly burst forth in the constellation of the Northern Crown. Thanks to the kindness of the first discoverer of this phenomenon, Mr. Birmingham, of Tuam, the speaker was enabled, conjointly with Dr. Miller, to examine the spectrum of this star on the 16th of May, when it had not fallen much below the 3rd magnitude.

The spectrum of this star consists of two distinct spectra. One of these is formed of four bright lines. The other spectrum is analogous to the spectra of the sun and stars.

These two spectra represent two distinct sources of light. Each spectrum is formed by the decomposition of light, which is independent of the light which gives birth to the other spectrum.

The continuous spectrum, crowded with groups of dark lines, shows that there exists a photosphere of incandescent solid or liquid matter. Further, that there is an atmosphere of cooler vapours, which give rise, by absorption, to the group of dark lines.

So far the constitution of this object is analogous to that of the sun and stars; but, in addition, there is the second spectrum, which consists of bright lines. There is therefore a second and distinct source of light, and this must be, as the character of the spectrum shows, *luminous gas*. Now the two

principal of the bright lines of this spectrum inform us, by their position, that one of the luminous gases is *hydrogen*. The great brightness of these lines shows that the luminous gas is hotter than the photosphere. These facts, taken in connexion with the suddenness of the outburst of light in the star and its immediate very rapid decline in brightness, *from the 2nd magnitude down to the 8th magnitude in twelve days*, suggested the startling speculation that *the star* had *become suddenly enrapt in the flames of luminous or burning hydrogen.* In consequence, it may be, of some great convulsion enormous quantities of gas were set free. A large part of this gas consisted of hydrogen, which was either intensely glowing, or burning about the star in combination with some other element. This flaming gas emitted the light represented by the spectrum of bright lines. The spectrum of the other part of the star's light may show that this fierce gaseous conflagration had heated to a more vivid incandescence the solid matter of the photosphere. As the free hydrogen became exhausted the flames gradually abated, the photosphere became less vivid, and the star waned down to its former brightness.

We must not forget that light, though a swift messenger, requires time to pass from the star to us. The great physical convulsion, which is new to us, is already an event of the past with respect to the star itself. For years the star has existed under the new conditions which followed this fiery catastrophe.

Nebulæ.

When the eye is aided by a telescope of even moderate power, a large number of faintly luminous patches and spots come forth from the darkness of the sky, which are in strong contrast with the brilliant but point-like images of the *stars*. A few of these objects may be easily discerned to consist of very faint stars closely aggregated together. Many of these strange objects remain, even in the largest telescopes, unresolved into stars, and resemble feebly shining clouds or masses of phosphorescent haze. During the last 150 years the intensely important question has been continually before the mind of astronomers, "What is the true nature of these faint, comet-like masses?"

The interest connected with an answer to this question has much increased since Sir Wm. Herschel suggested that these objects are portions of the primordial material out of which the existing stars have been fashioned; and further, that in these objects we may study some of the stages through which the suns and planets pass in their development from luminous cloud.

The telescope has failed to give any certain information of the nature of the nebulæ. It is true that each successive increase of aperture has resolved more of these objects into bright points, but at the same time other fainter nebulæ have been brought into view, and fantastic wisps and diffused patches of light have been seen, which the mind almost refuses to believe can be due to the united glare of innumerable suns still more remote.

Spectrum analysis, if it could be successfully applied to objects so excessively faint, was obviously a method of investigation specially suitable for determining whether any essential physical distinction separates the nebulæ from the stars.

The speaker selected for the first attempt, in August 1864, one of the class of small, but comparatively bright nebulæ.

His surprise was very great, on looking into the small telescope of the spectrum apparatus, to perceive that there was no appearance of a band of coloured light, such as a star would give; but in place of this, there were

three isolated *bright lines* only. The spectrum of this nebula is represented in fig. 5 of Plate III.

This observation was sufficient to solve the long-agitated inquiry in reference to this object at least, and to show that it was not a *group of stars*, but a *true nebula.*

A spectrum of this character, so far as our knowledge at present extends, can be produced only by light which has emanated from matter in the *state of gas*. The light of this nebula, therefore, was not emitted from incandescent solid or liquid matter, as is the light of the sun and stars, but from *glowing or luminous gas.*

It was of importance to learn, if possible, from the *position* of these bright lines, the chemical nature of the gas or gases of which this nebula consists.

Measures taken by the micrometer of the most brilliant of the bright lines showed that this line occurs in the spectrum very nearly in the position of the brightest of the lines in spectrum of nitrogen. The experiment was then made of comparing the spectrum of nitrogen directly with the bright lines of the nebulæ. The speaker found that the brightest of the lines of the nebulæ *coincided* with the strongest of the group of lines which are peculiar to nitrogen. It may be, therefore, that the occurrence of this one line only indicates a form of matter more elementary than nitrogen, and which our analysis has not yet enabled us to detect.

In a similar manner the faintest of the lines was found to coincide with the line of hydrogen coincident with F.

The middle line of the three lines which form the spectrum of the nebula does not coincide with any very strong line in the spectra of about thirty of the terrestrial elements. It is not far from a line of barium, but it does not coincide with it. Besides these bright lines there was also an exceedingly faint continuous spectrum. The spectrum had no apparent breadth, and must therefore have been formed by a minute point of light. Its position, crossing the bright line about the middle, showed that the point of light was situated about the centre of the nebula. Now this nebula possesses a minute but bright nucleus. We learn from this observation that the matter of the nucleus is almost certainly not in a state of gas, as is the material of the surrounding nebula. It consists of opake matter, which may exist in the form of an incandescent fog of solid or liquid particles.

The new and unexpected results arrived at by the prismatic examination of this nebula showed the importance of examining as many as possible of these remarkable bodies. Would all the nebulæ give similar spectra? Especially it was of importance to ascertain whether those nebulæ which the telescope had certainly resolved into a close aggregation of bright points would give a spectrum indicating gaseity.

The observation with the prism of these objects is extremely difficult, on account of their great faintness. Besides this, it is only when the sky is very clear and the moon is absent that the prismatic examination of their light is even possible. During the last two years the speaker has examined the spectra of more than 60 nebulæ and clusters. These may be divided into two great groups. One group consists of the nebulæ which give a spectrum similar to the one already described, or else of one or two only of the three bright lines. Of the 60 objects examined about one-third belong to the class of gaseous bodies. The light from the remaining forty nebulæ and clusters becomes spread out by the prism into a spectrum which is *apparently* continuous.

A remarkable nebula, and possibly one of the nearest to our system, of the nebulæ presenting a *ring formation*, is the well-known Annular Nebula in Lyra. The spectrum consists of one bright line only. When the slit of the instrument crosses the nebula, the line consists of two brighter portions corresponding to the sections of the ring. A much fainter line joins them, which shows that the faint central portion of the nebula has a similar constitution.

A nebula remarkable for its large extent and peculiar form is that known as the *Dumb-bell Nebula*. The spectrum of this nebula consists of one line only. A prismatic examination of the light from different parts of this object, showed that it is throughout of a similar constitution.

The most widely known, perhaps, of all the nebulæ is the remarkable cloud-like object in the sword-handle of Orion.

This object is also gaseous. Its spectrum consists of three bright lines. Lord Rosse informed the speaker that the bluish-green matter of the nebula has not been resolved by his telescope. In some parts, however, he sees a large number of very minute *red* stars, which, though apparently connected with the irresolvable matter of the nebula, are yet doubtless distinct from it. These stars would be too faint to furnish a visible spectrum.

All the true *Clusters*, which are resolved by the telescope into distinct bright points, give a spectrum, which does not consist of separate bright lines, but is *apparently* continuous in its light. There are many *nebulæ* which furnish a similar spectrum.

As an example of these nebulæ, the great nebula in Andromeda may be taken, which is visible to the naked eye, and is not seldom mistaken for a comet. The spectrum of this nebula, though apparently continuous, has some suggestive peculiarities. The whole of the red and part of the orange are wanting. Besides this character, the brighter parts of the spectrum have a very unequal and mottled appearance.

It is remarkable that the easily resolved cluster in Hercules has a spectrum precisely similar. The prismatic connexion of this cluster with the nebula in Andromeda is confirmed by telescopic observation. Lord Rosse has discovered in this cluster dark streaks or lines similar to those which are seen in the nebula in Andromeda.

In connexion with these observations, it was of great interest to ascertain whether this broad classification afforded by the prism of the nebulæ and clusters, would correspond with the indications of resolvability furnished by the telescope. Would it be found that all the *unresolved* nebulæ are *gaseous*, and that those which give a *continuous spectrum* are *clusters of stars*?

Lord Oxmantown has examined all the observations of the 60 nebulæ and clusters in the speaker's list, which have been made with the great reflecting telescope erected by his father, the Earl of Rosse.

The results are given in the following Table:—

	Continuous spectrum.	Gaseous spectrum.
Clusters	10	0
Resolved, or resolved?	5	0
Resolvable, or resolvable?	10	6
Blue or green, no resolvability,	0	4
no resolvability seen	6	5
	31	15
Not observed by Lord Rosse	10	4
	41	19

Considering the great difficulty of successful telescopic observation of these

objects, the correspondence between the results of prismatic and telescopic observation may be regarded as close and suggestive.

Half of the nebulæ which give a continuous spectrum have been resolved, and about one-third more are probably resolvable; while of the gaseous nebulæ *none have been certainly resolved*, according to Lord Rosse.

The inquiry now presses itself upon us—What superstructure of interpretation have we a right to raise upon the new facts with which the prism has furnished us?

Is the existence of the gaseous nebulæ an evidence of the reality of that primordial nebulous matter required by the theories of Sir William Herschel and Laplace?

Again, if we do not accept the view that these nebulæ are composed of portions of the original elementary matter out of which suns and planets have been elaborated, what is the cosmical rank and relation which we ought to assign to them? As aids to a *future* determination of these great questions, some other observations made by the speaker may be briefly referred to.

Comets.

There are objects in the heavens which occasionally, and under some conditions, resemble closely some of the nebulæ. In some positions in their orbits some of the comets appear as round vaporous masses, and except by their motion, cannot be distinguished from nebulæ. Does this occasional general resemblance indicate a similarity of nature? In 1864 Donati found that the spectrum of a comet visible in that year consisted of *bright lines*.

Last January a small telescopic comet was visible. It was a nearly circular, very faint vaporous mass. Nearly in the centre, a small and rather dim nucleus was seen. When this object was viewed in the spectroscope, two spectra were distinguished. A very faint continuous spectrum of the coma showed that it was visible by reflecting the solar light. About the middle of this faint spectrum, a bright point was seen. This bright point is the spectrum of the nucleus, and shows that its light is different from that of the coma. This short bright *line* indicates that the nucleus of this comet was self-luminous; and further, the position of this line of the spectrum suggests that the material of the comet might possibly be similar to the matter of which the gaseous nebulæ consist.

Measures of the intrinsic brightness of the Nebulæ.

It appeared to the speaker that some information of the nature of the nebulæ might be obtained from observations of another order. If physical changes of the magnitude necessary for the conversion of these gaseous bodies into suns are now in progress in the nebulæ, surely this process of development would be accompanied by marked changes in the intrinsic brightness of their light, and in their size.

Now since the spectroscope shows these bodies to be continuous masses of gas, it is possible to obtain an approximate measure of their *real brightness*. It is known that as long as a distant object remains of sensible size, its brightness remains unaltered. By a new photometric method the *intrinsic* intensity of the light of three of the gaseous nebulæ was found in terms of a sperm candle burning at the rate of 158 grains per hour.

Nebula No. 4628	$\frac{1}{1508}$ part of the intensity of the candle.			
Annular Nebula in Lyra ..	$\frac{1}{6032}$	,,	,,	,,
Dumb-bell Nebula	$\frac{1}{19604}$	,,	,,	,,

These numbers represent not the *apparent* brightness only, but the *true brightness* of these luminous masses, except so far as it may have been diminished by a possible power of extinction existing in cosmical space, and by the absorption of our atmosphere. It is obvious that similar observations, made at considerable intervals of time, may show whether the light of these objects is undergoing increase or diminution, or is subject to a periodic variation. If the dumb-bell nebula, the feeble light of which is not more than one twenty-thousandth part of that of a candle, be in accordance with popular theory a *sun-germ*, then it is scarcely possible to put in an intelligble form the enormous number of times by which its light must increase before this faint nebula, feebler now in its glimmering than a rushlight, can rival the dazzling splendour of our sun.

Measures of the Nebulæ.

Some of the nebulæ are sufficiently defined in outline to admit of accurate measurement. By means of a series of micrometric observations, it will be possible to ascertain whether any considerable alteration in size takes place in nebulæ.

Meteors.

Mr. Alexander Herschel has recently succeeded in subjecting another order of the heavenly bodies to prismatic analysis. He has obtained the spectrum of a bright meteor, and also the spectra of some of the trains which meteors leave behind them. A remarkable result of his observations appears to be that sodium in the state of luminous vapour is present in the trains of most meteors.

Conclusion.

In conclusion, the new knowledge that has been gained from these observations with the prism may be summed up as follows :—

1. All the brighter stars, at least, have a structure analogous to that of the sun.
2. The stars contain material elements common to the sun and earth.
3. The colours of the stars have their origin in the chemical constitution of the atmospheres which surround them.
4. The changes in brightness of some of the variable stars are attended with changes in the lines of absorption of their spectra.
5. The phenomena of the star in Corona appear to show that in this object at least great physical changes are in operation.
6. There exist in the heavens *true nebulæ*. These objects consist of luminous gas.
7. A part of the light of comets is self-luminous.
8. The bright points of the star-clusters may not be in all cases stars of the same order as the separate bright stars.

It may be asked what cosmical theory of the origin and relations of the heavenly bodies do these new facts suggest? It would be easy to speculate, but it appears to me that it would not be philosophical to dogmatize at present on a subject of which we know so very little. Our views of the universe are undergoing important changes ; let us wait for more facts with minds unfettered by any dogmatic theory, and therefore free to receive the obvious teaching, whatever it may be, of new observations.

Star differs from star in glory, each nebula and each cluster has its own special features, doubtless in wisdom and for high and important purposes the Creator has made them all.

On some further Results of Spectrum Analysis as applied to the Heavenly Bodies. By William Huggins, *F.R.S., Hon. Sec. to the Royal Astronomical Society**.

[Plate V.]

Two years ago, at the Meeting of the British Association at Nottingham, I had the honour to give, in an evening discourse, a summary of the results of Spectrum Analysis as applied to the heavenly bodies, which had been obtained partly by myself and partly as the conjoint work of myself and Dr. W. Allen Miller, Treas. and V.P.R.S.

I beg now to offer to the Association a brief account of some of the principal results of the observations which I have made since August 1866.

These observations may be arranged according to the classes of the heavenly bodies to which they relate.

§ I. On the Fixed Stars.
§ II. On the Nebulæ.
§ III. On the Light of Comets.
§ IV. On the Spectra of Sun-spots.
§ V. On the Planets.

§ I. On the Fixed Stars.

A. *Observations to determine whether the Stars are moving towards or from the Earth.*

The determination of the proper motions of stars from observations of their angular motions among the stars apparently near them, gives to us information of that part only of their motion which is at right angles to a ray of light coming from the star to the observer. It would be a rare accident only if the motion thus obtained represented the whole of their motion. The other part of the star's motion, namely, the movement of the star in the direction of the visual ray towards or from the earth, seemed to be beyond the reach of our means of observation; for photometric estimation of the increase or diminution of the light of the star was obviously too coarse and uncertain a method for so delicate an investigation.

Now it is precisely information on this point which appeared to be inaccessible to us, which has been brought within our reach by means of observations with the prism. Supposing waves to be coming in upon the shore, a ship leaving the harbour would encounter a larger number of these waves in a given time than a ship would at anchor; and further, the increased velocity of succession of the waves which would strike its prow could be determined if the velocity of the ship and that of the waves were known. Conversely, if the period and the velocity of the waves had been ascertained, the captain, by counting the number of waves which met the ship in a given interval of time, could determine therefrom the motion of his vessel. A little consideration will make it evident that a similar effect would take place if the vessel were at rest, and the source of wave-motion were supposed to approach or recede from the vessel; in this case the velocity of the source of wave-motion could be determined, if the initial period of the waves and the velocity of their propagation were known. This illustration sets forth the principles on which is founded the method of investigation which is now to be described.

The idea that a change of period in luminous or sonorous waves would arise in consequence of a motion of the observer, or of the source of the light,

* A communication ordered to be printed *in extenso*.

Fig. 1.

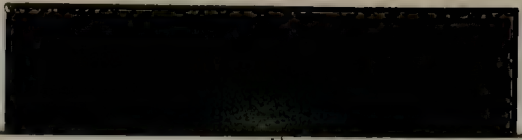


Fig 2.

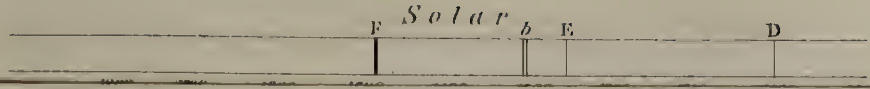


Fig. 3.

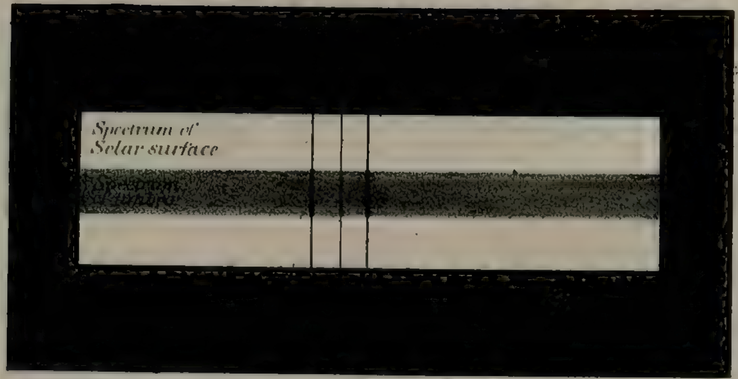


Fig. 4.

Huggins.

J. Basire, lith.

Fig. 1

Fig. 2

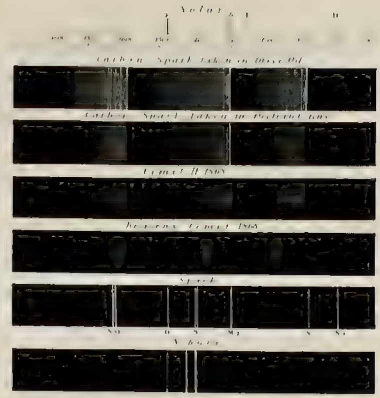


Fig. 3

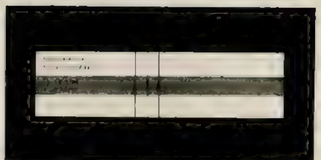


Fig. 4

or of the sound, towards or from each other, is due to Doppler. In 1841 Doppler showed that since the impression which is received by the eye or the ear does not depend upon the *intrinsic* strength and period of the waves of light and of sound, but is determined by the interval of time in which they fall upon the organ of the observer, it follows that the colour and intensity of an impression of light and the pitch and strength of a sound will be altered by a motion of the source of the light or of the sound, or by a motion of the observer, towards or from each other *.

Doppler then went wrong; for he sought by these considerations to account for the remarkable difference of colour which some of the binary stars present, and for some other phenomena of the heavenly bodies. Now it is obvious that if a star could be conceived to be moving with a velocity sufficiently great to alter its colour sensibly to the eye, still no change of colour would be perceived, for the reason that, beyond the visible spectrum, at both extremities there exists a store of invisible waves which would be at the same time exalted or degraded into visibility to take the place of the waves which had been raised or lowered in refrangibility by the star's motion. No change of colour, therefore, could take place until the whole of these invisible waves of force had been used up, which would only be the case when the relative motion of the source of light and of the observer was several times greater than that of light.

It is obvious from these considerations that this method of research could afford us information of the motion of the star only in the case in which *we knew the period of the light at the time of its emission from the star*; for then a comparison of this initial period with that observed at the earth would show the exact amount of the change of refrangibility due to the relative motions of the observer and the star, and as the earth's motions are known, the motion of the star could be determined.

Now this one essential condition, namely, the knowledge of the period of the light when emitted by the star, is fulfilled by spectrum analysis. When we learn the existence of a terrestrial substance in a star, we have the means of knowing the initial refrangibility of the dark lines in the star's spectrum, which are due to the absorption of the vapour of this substance.

It may be thought that if the lines in the spectra of the stars are subject to an unknown amount of displacement from the cause we have now under consideration, it would not be possible to make use of these lines to learn the star's chemical constitution. This objection, however, does not obtain; for the amount by which the lines would be displaced by any velocity we could with probability assign to the stars, would be too small to be even perceived in the spectroscopes which had hitherto been applied to the heavenly bodies. For example, a velocity ten times greater than that of the earth in its orbit would cause a line to move through a space in the spectrum about as great as that which separates the components of the double line D of the solar spectrum. Besides this consideration, the trustworthiness of the results obtained by myself and Dr. Miller in our joint researches, was not allowed to rest upon the position of a single line, but upon the coincidence in general character as well as in position of a *group of several lines*. At the time, indeed, when we made our observations, we were fully aware that these direct comparisons were not only of value for the determination of the chemical constitution of the stars, but that they might tell us something of the motions

* "Ueber das farbige Licht der Doppelsterne und einiger anderer Gestirne des Himmels," Böhm. Gesell. Abh. ii. 1842–44, s. 465.

of the stars relatively to our system. The great velocity of light relatively to the known planetary velocities and to the probable motions of the few stars of which the parallax is known, showed that any alterations of position which might be expected from this cause in the lines of the stellar spectra would not exceed a fraction of the interval between the double line D, a change which could not be detected in our instrument. We were, however, in possession of the information that the stars, the spectra of which had been compared with the necessary care, were not moving towards or from the earth with a velocity so great as 190 miles per second. Among these stars are Aldebaran, α Orionis, β Pegasi, Sirius, α Lyræ, Capella, Arcturus, Pollux, and Castor.

Recently (in 1866) Klinkerfues published a memoir on the influence of the motion of a source of light upon the refrangibility of its rays, and described therein a series of observations, from which he deduces certain amounts of motion in the case of some objects observed by him. As Klinkerfues employs an achromatic prism, it does not seem possible by his method to obtain any information of the motions of the stars; for in such a prism the difference of period of the luminous waves would be as far as possible annulled. It is, however, conceivable that his observations of the light when travelling from E. to W., and from W. to E., might show a difference in the two cases, arising from the earth's motion through the ether*.

Father Secchi has quite recently called attention to this subject. In his paper he states that he has not been able to detect any change of refrangibility in the case of certain stars of an amount equal to the difference between the components of the double line D. These results are in accordance with those obtained by Dr. Miller and myself in 1863, so far as they refer to the stars whith had been examined by us. Father Secchi's method of using an unrefracted image as a fiducial mark, with diverging rays passing through the prisms, might, it is conceivable, be open to objection. He appears to consider that, to produce a certain alteration of refrangibility, half the velocity would be required in the case of the approach of a star, of that which would be necessary if the star were receding. This is not the case; for equal velocities of separation or approach give equal change of wave-length. It is true that a difference of an octave is produced by a relative velocity of separation equal to that of light, and by a velocity of approach equal to half that of light; but the difference in length of a wave and its octave below (which is twice as long) is, in the same proportion, greater than the difference between it and the octave above (which is half as long)†.

The subject of the influence of the motions of the heavenly bodies on the index of refraction of light had already (in 1864) occupied the attention of Mr. Maxwell, F.R.S., who made some experiments in an analogous direction. In the spring of last year Mr. Maxwell sent to me a statement of his views and experiments, which he has permitted me to include in a paper presented by me to the Royal Society‡.

Mr. Maxwell puts the subject in the following way:—

"Let a source of light be such that it produces n disturbances or vibrations per second, and let it be at such a distance from the earth that the light requires a time T to reach the earth. Let the distance of the source of light from the earth be altered, either by the motion of the source of light,

* "Fernere Mittheilungen über den Einfluss der Bewegung der Lichtquelle auf die Brechbarkeit eines Strahls, von W. Klinkerfues," Nachr. der K. G. der W. zu Göttingen, No. 4, s. 33.

† Comptes Rendus, 2 Mars 1868, p 398.

‡ Phil. Trans. 1868.

or by that of the earth, so that the light which emanates from the source t seconds afterwards reaches the earth in a time T'.

"During the t seconds $n\,t$ vibrations of the source of light took place, and these reached the earth between the time T and the time $t+T'$, that is, during $t+T'-T$ seconds. The number of vibrations which reached the earth per second was, therefore, no longer n, but $n\,\frac{t}{t+T'-T}$.

"If v is the velocity of separation of the source of light from the earth, and V the velocity of the light between the bodies, then $v\,t=V(T'-T)$, and the number of vibrations per second at the earth will be $n\,\frac{V}{V+v}$.

"If, therefore, the light of a star be due to sodium, or be absorbed by vapour of sodium, then the light, when it reaches the earth, will have an excess or defect of rays whose period of vibration is to that of the period of sodium as $V+v$ is to V."

There is another quite distinct way in which, under some circumstances, it is conceivable that an alteration of refrangibility might take place. If the motion of the luminiferous medium be different from that of the earth, that is, does not accompany the earth in its motion, a deviation might be expected, according to the *direction* of the ray within the prisms. The essentials of this experiment are entirely terrestrial, and depend only on the relative motion of the prism and the luminiferous medium, and on the direction in which the ray passes through the prism. Mr. Maxwell has made some careful experiments in this direction, but has obtained only negative results.

Several of my early attempts failed in consequence of insufficient dispersive power in the apparatus employed. It was only after several quite distinct forms of apparatus were successively constructed, that I succeeded in obtaining an instrument suitable for these very delicate observations.

A serious difficulty presented itself from the inconvenience, and in some degree untrustworthiness for this investigation, of the ordinary method of reflecting into the instrument a spectrum of comparison, by means of a small prism placed over one half of the slit, even when the precautions described in my papers presented to the Royal Society, for the purpose of ensuring perfect accuracy in relative position in the instrument of the star-spectrum with that to be compared with it, were carefully observed.

A description of the apparatus which I finally adopted, and which appears in all respects trustworthy, is contained in the paper presented to the Royal Society. This apparatus gave an amount of dispersion equal to about seven prisms of dense flint glass of 60°.

The chief difficulties I encountered arose from the unsteadiness of our atmosphere. Stars of the first and second magnitude give sufficient light for examination with the large spectroscope described; but unless the air is exceptionally steady, the lines are seen too fitfully to permit of any certainty in the determination of coincidence, of the great degree of delicacy required. From this cause, the work of very many nights has had to be rejected. I will describe here those observations only which have led to a successful result.

Sirius.—The brilliant light of *Sirius*, and the great intensity of four strong lines of its spectrum, made this star specially suitable for my purpose, though from its low altitude in our latitude, it can be successfully observed for an hour only on each side of the meridian.

The coincidence of two of the strong lines of this star with those of

hydrogen, had been satisfactorily determined by myself and Dr. Miller in 1863. We found also in the star lines coincident with some of those of iron, magnesium, and sodium. Of all these lines, the one which corresponds to F of the solar spectrum was alone seen with the steady distinctness necessary for comparison, when the powerful train of prisms was used.

We have sufficient proof from our observations referred to, that this line is produced by hydrogen; at the time, therefore, of its formation at the star, its period would be identical with that of the corresponding line of hydrogen.

This line in the star appears rather broader than in the solar spectrum; it includes, perhaps, a range of wave-length about equal to that of the separation of the double line D; it is in a small degree nebulous at both edges.

As the corresponding bright line of the spectrum of hydrogen, when the spark is taken in hydrogen at the pressure of the atmosphere, is too expanded for accurate comparison, the hydrogen was employed as it exists in the so-called vacuum-tubes. In this state the hydrogen gives a narrow and well-defined line.

The result of a great many comparisons on many nights is to show that the bright line of hydrogen is, in a small degree, more refrangible than the dark line in the star (see fig. 4, Pl. V.). The amount of degradation in wave-length which the line had suffered, was found to be equal to 0·109 millionth of a millimetre.

If the velocity of light be taken at 185,000 miles per second, and the wave-length of F at 486·50 millionths of a metre, the alteration in period observed in the line of Sirius will indicate a motion of recession between the earth and the star of 41·4 miles per second.

Of this motion a part is due to the earth's motion in space. As the earth moves round the sun in the plane of the ecliptic, it is changing the direction of its motion at every instant. There are two positions separated by 180°, where the effect of the earth's motion is a maximum, namely, when it is moving in the direction of the visual ray, either towards or from the star. At two other positions in its orbit, at 90° from the former positions, the earth's motion is at right angles to the direction of the light from the star, and therefore has no influence on the refrangibility of its light.

The position of the star is also of importance; for the effect of the earth's motion will be greatest upon the light of a star situated in the plane of the ecliptic, and will decrease as the star's latitude increases, until, with respect to a star at the pole of the ecliptic, the earth's motion, during the whole of its annual course, will be perpendicular to the direction of the light coming to us from it, and will be therefore without influence on the period of the light.

Now at the time the observations on Sirius were made, the earth was moving from the star with a velocity of twelve miles per second. *There remains, therefore, a motion from the earth of 29·4 miles per second, which appears to belong to the star itself.*

The solar motion in space will not materially affect this result; for, according to Struve, the sun advances in space with a velocity but little greater than one-fourth of the earth's orbital motion. If the apex of the solar motion be situated in Hercules, nearly the whole of it will be from Sirius, and will therefore diminish the velocity to be ascribed to that star.

It is interesting to remark that at the present time the proper motion of Sirius in declination is less than its average amount by nearly the whole of that part of it which is subject to variation. It may be that a greater part of the star's motion is now in the direction of the visual ray.

It must not be forgotten that the whole of the proper motion which can be directly observed by us, consists of that portion only which is at right angles to the visual ray. This motion, according to the parallax we attribute to Sirius (Henderson$=0''\cdot150$, Abbe$=0''\cdot27$), will vary from 24 miles to 43 miles per second.

The real motion of the star will consist of this motion, combined with the motion at right angles to it, obtained by the present investigation, of 29 miles *from* the earth.

Similar observations have been made of several other stars; I desire, however, to submit them to a re-examination.

B. *Other Spectroscopic Observations of the Fixed Stars.*

α Herculis.—On several occasions the spectrum of this star was re-examined. The observations agree with the measures and comparisons of the chemical elements of this star obtained in 1863. The spectrum is continuous, with numerous groups of dark lines.

Mira Ceti gives a spectrum apparently identical, or nearly so, with *α* Orionis. At the time the star was waning in brightness there was an appearance of greater intensity in several of the groups, but further observations are required before any opinion is hazarded as to the cause of its remarkable periodical variation in brightness.

γ Cassiopeiæ.—In addition to the bright line near the boundary of the green and blue observed by Father Secchi, I discovered a line of equal brilliancy in the red. There are also in the spectrum of this star dark lines due to absorption. The two bright lines are narrow and defined, but are not very brilliant. Micrometrical measures of these bright lines show that they are doubtless coincident in position in the spectrum with Fraunhofer's C and F, and with two of the bright lines of luminous hydrogen.

I have confirmed the interesting observations of MM. Wolf and Rayet, so far as to the presence of bright lines in the three small stars described by them. I have not determined the number and positions of these lines.

§ II. Observations of the Nebulæ.

My observations on these bodies have confirmed the results of my former investigation, but have not afforded much information which is new. Out of about seventy nebulæ, nearly one-third gave a spectrum of bright lines.

The differences which have been observed between the spectra of the objects which give bright lines, may be regarded as modifications only of the typical form of spectrum represented in fig. 2. Pl. V.

The variations consist of differences of relative intensity, and, in some cases, of the absence of one or two of the lines. It is worthy of remark that, so far as the nebulæ have been observed, the brightest of the three lines, which is coincident with a line of nitrogen, is always present, and sometimes the spectrum consists wholly of this line. It is a suggestive fact that in no nebula have any additional lines been observed on the less refrangible and brighter side of the line common to all the nebulæ. In two or three nebulæ a fourth line, more refrangible than those represented in the diagram, has been detected.

The spectrum of the *Great Nebula in Orion* was observed and compared with terrestrial lines, in the powerful spectroscope described in this paper.

The coincidence of the strongest line with a double line of nitrogen, though now subjected to a much more severe trial (to a spreading out of the spectrum nearly three times greater than in my former observations), appeared as perfect as before.

I was not able, even with this great dispersive power, and after long and careful scrutiny directed to this point, to discover any duplicity in the line of the nebula corresponding to that which characterizes the line of nitrogen. The line of the nebula appeared to me narrower, under the same circumstances of slit, than the double line of nitrogen; but the latter line may have appeared broader in consequence of irradiation, as it was brighter than the line of the nebula. It is worthy of remark that when the induction spark was placed before the object-glass, the line of nitrogen was so much fainter that it ceased to appear double, and resembled the nebular line *.

The third line of this nebula was also compared, with equal care, with the narrow line of hydrogen when the spark is taken in rarefied hydrogen. The coincidence of the line of the nebula with that of hydrogen appeared to be perfect.

Now these coincidences with hydrogen and nitrogen were made with an apparatus in which a difference in wave-length of 0·0460 millionth of a millimetre would have been detected. The great probability that these lines are emitted by hydrogen and nitrogen existing in the nebula, appears by these observations to be strengthened almost to certainty. We learn also that the nebula was not receding from us with a velocity greater than 10 miles per second; for this motion, in addition to the earth's motion in the same direction at the time, would have caused a want of coincidence that could have been observed. If, however, the nebula were approaching us it might have a velocity as great as 20 miles per second; for part of this motion would be annulled by the earth's motion in a contrary direction.

It was found that when the intensity of the spectrum of nitrogen was greatly diminished by removing the induction-spark in nitrogen to a distance from the slit, the whole spectrum disappeared with the exception of the double line, which agrees in position with the line in the nebulæ, so that under these circumstances the spectrum of nitrogen resembled the monochromatic spectrum of some nebulæ. It is obvious that if the spectrum of hydrogen were similarly reduced in intensity, the strong line in the blue, which corresponds to the third line of the nebular spectrum, would remain visible after the line in the red and the lines more refrangible than F had become too feeble to affect the eye.

These observations suggest the interesting question, whether the few lines of the spectra of these objects represent the whole of the light emitted by them, or whether these lines are the strongest lines only of their spectra which have succeeded in reaching the earth. At present we have no positive evidence on this point. Since these bodies have a sensible diameter, and in all probability present a continuous luminous surface, we can hardly suppose that any lines have been extinguished by the effect of the distance of the objects from us. If we should ever have reason to believe that the other lines which are present in the spectra of nitrogen and hydrogen are quenched on their way to us, we should, it seems, have to regard their disappearance as an indication of a power of extinction residing in cosmical space, similar to that which was suggested from theoretical considerations by Chéseaux, and afterwards supported on other grounds by Olbers and the elder Struve.

* Secchi, indeed, states that with his direct spectroscope this line in the annular nebula in Lyra was double. As, however, the image of the nebula was viewed directly after elongation by a cylindrical lens, and without a slit, it is probable that the two lines may correspond to the two sides of the elongated annulus of the nebula.

§ III. Observations of Comets.

As soon as I had successfully applied the analysis by the prism to the light of the nebulæ, it appeared to me to be of great importance to subject the light of comets to a similar examination, especially as we possessed no certain knowledge of the intimate nature of these singular and enigmatical bodies, or of the cosmical relations they may sustain to the solar system.

Several attempts which I made to obtain a prismatic observation of Comet I., 1864, were rendered unsuccessful by the position of the comet, and by unfavourable weather. M. Donati succeeded in making an observation of its spectrum. He describes it as consisting of three bright bands *.

In the discourse I had the honour to give before the Association at Nottingham, I described the results of the analysis of a very small and faint comet, Comet I. 1866. Its spectrum was compound, and showed that the nucleus was self-luminous, and the surrounding coma was visible by reflecting solar light. The position of the bright line, into which the light of the nucleus was resolved, appeared, as far as the faintness of the object permitted a determination, not to differ greatly from that of the brightest line of the nebulæ. I was led by this circumstance to suggest that possibly the material of the comet was similar to the matter of which the gaseous nebulæ consist. A subsequent examination of three other comets, of which the principal results will be given in this paper, shows that this suggestion of the identity of the material of comets with that of some of the nebulæ cannot be maintained.

The spectrum of a faint comet examined in May 1867 resembled that of Comet I., 1866. The light of the self-luminous nucleus gave a line between *b* and F, and the coma was represented by a continuous spectrum, which showed that it reflected solar light.

Brorsen's Comet.

From May 2 to May 13 I examined the spectrum of Brorsen's comet at its reappearance in 1868. This comet was brighter than the two comets I had previously examined; and I was, from this cause, enabled to obtain a fuller and more complete analysis of its light.

Its spectrum, as seen in a spectroscope furnished with two prisms of dense flint glass, with a refracting angle of 60°, is represented in fig. 2. Pl. V.

The comet appeared in the telescope as a nearly round nebulosity, in which the light increases rapidly towards the centre, where on some occasions I detected, I believe, a small nucleus.

The spectrum consisted, for the most part, of three bright bands, into which the light of the brighter portions of the coma was dispersed. These bands I was unable to resolve into *lines*, even when the slit was made narrow.

The position of the bands was determined by micrometrical measures, and also by the simultaneous comparison of them with the bright lines of magnesium, sodium, hydrogen, and nitrogen. The brightest band, which may be considered to represent about three-fourths of the whole light of the comet, occurs between *b* and F, and is, in a small degree, less refrangible than the line of nitrogen with which the brightest of the three lines of the nebulæ is coincident. The band in the blue was considerably more refrangible than F, and was nearly as refrangible as the group of bright lines in the air-spectrum which have the numbers 2642 to 2669 in the maps and tables of

* Monthly Notices of the Royal Astronomical Society, vol. xxv. p. 490; and Astronomische Nachrichten, No. 1488.

my paper "On the Spectra of the Chemical Elements" *. The least refrangible of the bands occurred in the yellow portion of the spectrum at about the distance from E of one-third of the interval which separates E from D.

In Brorsen's comet, at the time of the observations, the whole of the bright middle part of the nebulosity forming the coma was self-luminous, and it was only the extreme very faint portions of the object which gave a continuous spectrum.

COMET II., 1868.

On June 18 a comet was discovered by Dr. Winnecke at Carlsruhe, and also independently the same night by M. Becquet, Assistant-Astronomer at the observatory of Marseilles.

On June 22 I examined this comet, which consisted of a nearly circular coma, which became rather suddenly brighter towards the centre, where there was a nearly round spot of light; from this a tail was traced for nearly a degree (see fig. 1. Pl. V.).

When a spectroscope, furnished with two prisms of 60°, was applied to the telescope, the light of the comet was resolved into three very broad bands, which, as will be seen in the diagram, do not correspond exactly to the bright bands of Brorsen's comet.

In the two more refrangible bands the light was brightest at the less refrangible limit, and gradually diminished towards the other side of the bands. In the middle and brightest band the gradation of light was not uniform, but continued of nearly equal brilliancy for a distance from the less refrangible side of about one-third of the breadth of the band. This band appeared to be commenced at its brightest side by a distinct bright line.

The least refrangible of the bands did not exhibit a similar gradation of brightness, but was rather brighter about the middle of its breadth.

It will be seen, by a reference to the diagram (fig. 2. Pl. V.), that the two more refrangible bands are longest at their brightest limits, and become shorter in the same proportion as they become fainter. This appearance does not show any difference between the light of the coma and of the bright central spot, but arises from the circumstance that the light of the comet becomes gradually fainter from the centre towards the circumference; and consequently the light which the eye perceives in the spectrum, though similar throughout, is too feeble to be perceived at the ends, as the bands become fainter. This obvious explanation is shown to be the right one by the appearance of the least refrangible band, in which a gradation of light did not take place. In this band the increase of light towards the centre of the coma showed itself as a bright axial line gradually fading off in both directions.

When the marginal positions of the coma were brought upon the slit, the three bright bands could still be seen; but when the light became very faint, the spectrum appeared to me to be continuous, but it was too faint to be traced beyond the positions of the bands, towards the violet, or the red. The tail was brought upon the slit, but I was unable, from its excessive faintness, to determine anything as to the character of its spectrum.

The bands are laid down in the diagram from careful measures obtained with the micrometer-screw attached to the small telescope of the spectrum-apparatus. When I compared the spectrum of the comet obtained in this way with some diagrams of the spectrum of carbon which I had prepared in 1864, I was much interested to find that the three bands of the comet's spectrum agreed exactly, not only in position, but also in their general cha-

* Phil. Trans. 1864, p. 151.

racters, with the spectrum of carbon as it appears when the induction-spark is taken in a current of olefiant gas.

These observations on the spectrum of carbon were undertaken in continuance of my researches on the "Spectra of the Chemical Elements." I have not yet made them public, as they are not so complete as I hope to make them.

It may be stated, as the general result of this investigation, that though in all cases the essential features of the spectrum of carbon remained unaltered, certain small modifications were observed when the spectrum was obtained under different conditions.

Two of these slightly modified forms of the spectrum of carbon are given in fig. 2. Pl. V. The first spectrum was obtained by taking the induction-spark between the points of platinum wires, sealed in glass tubes, and immersed in olive-oil. This spectrum may be taken as exhibiting the typical form of the spectrum of carbon. The brilliant line in the red part of the spectrum, which is in a small degree less refrangible than the line of hydrogen corresponding to Fraunhofer's C, is not seen when carbon is heated in the presence of hydrogen*.

The second spectrum in the diagram exhibits the slightly modified spectrum which is produced when the induction-spark passes in a current of olefiant gas†. It will be seen that the carbon emits light of the same refrangibility as in the former case; but the separate lines are no longer distinct, and the shading is not resolved into the numerous fine lines which were then visible. The very close agreement of the comet's spectrum with this form of the spectrum of carbon showed the importance of comparing the two spectra directly in the spectroscope.

On the following evening this was satisfactorily accomplished. My friend Dr. W. Allen Miller was present in the observatory on this evening, and kindly took part in the observations which were made.

A glass gas-holder, *a* (woodcut, p. 162), containing olefiant gas, was connected by a flexible tube with a glass tube, *b*, into which platinum wires were soldered. This tube was so fixed that the spark between the wires was suitably reflected by the small mirror, *c*, into the spectroscope attached to the telescope, so that the spectrum of carbon appeared directly below the spectrum of the comet.

We were satisfied that within the limits of the dispersive power of the instrument employed, which may be taken at about the breadth of the double line D, the two spectra were coincident, not only in the position of the bands, but also in their general characters, and their relative brightness.

This direct comparison I repeated on June 25, with an equally satisfactory result.

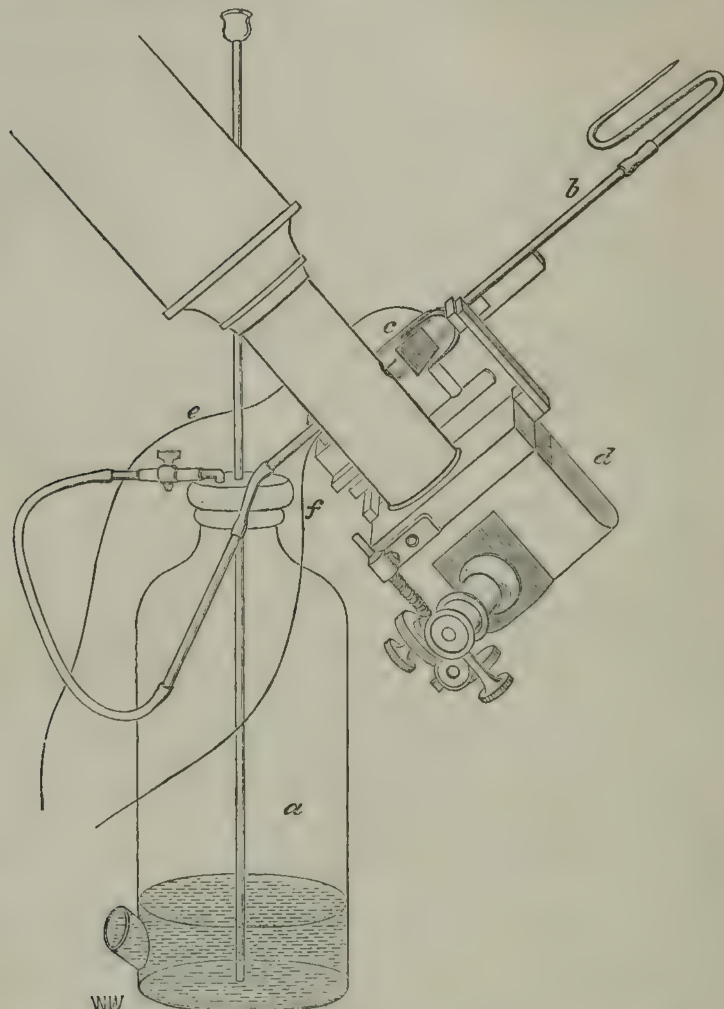
The lines of hydrogen (which, of course, were present in the spectrum of the olefiant gas) were not to be seen in the spectrum of the comet.

The very close resemblance of the spectrum of this comet to the spectrum of carbon necessarily suggests the identity of the substances by which, in both cases, the light was emitted, though indeed the great fixity of carbon seems to raise a difficulty in the way of accepting this conclusion. Some two or three comets have been known to approach the sun sufficiently near to acquire a temperature high enough to convert even carbon into vapour. Indeed for such comets a body of some fixity seems to be necessary. With

* Phil. Trans. 1864, p. 145.

† In the Plate the bright line at the beginning of the middle band of this spectrum is made too strong.

respect to the majority of comets, which are subjected to a less fierce glare of solar heat, it may be suggested that this supposed difficulty is one of degree only; for we do not know of any conditions under which even a gas permanent at the temperature of the earth could maintain sufficient heat to emit light



—a state of things which appears to exist permanently in the case of the gaseous nebulæ.

The important difference which exists between the spectrum of Brorsen's comet and that of Comet II., 1868, appears to show that the constitution of comets may possibly not be in all cases the same. In a paper presented to the Royal Society, I have ventured on some speculations with reference to the bearing of these observations on certain phenomena which are usually exhibited by comets.

§ IV. Observations of the Sun.

I have observed the sun with the spectroscope with three distinct objects in view:—

1. To discover if the light from the less luminous part of the sun near the limb gives a spectrum which differs in any respect from that which is

formed by the light from the bright central parts of the solar disk. I have as yet failed to detect any difference.

2. It appeared possible that a view of the red prominences visible during a solar eclipse might be obtained by reducing the light of our atmosphere by means of prismatic dispersion; for, under these circumstances, if the red prominences give a spectrum of bright lines, these lines would remain but little diminished in brightness, and might become visible. Observations with this object in view have been made during the last two years by different methods, but hitherto without success.

3. The third investigation, in which some success has been obtained, was with a view to gain, from an examination of the spectra of the umbræ and penumbræ of spots, some information as to the nature of these phenomena. I had already made some observations in this direction, when, in August 1866, I received a note from M. Faye, in which he suggests to me the prismatic examination of solar spots with reference especially to the theoretical views of the sun proposed by him.

My first observations were made with a small spectroscope, which was so arranged that the image of the sun was formed upon the slit after its heat had been enfeebled by reflection from a prismatic solar eyepiece. The principal solar lines were observed to be stronger in the spectrum of the light from the umbra.

I use the term "umbra" to describe the whole of the dark part within the penumbra, since it was not possible in these observations to distinguish the two distinct parts of which, in most spots, it is seen to consist, namely, the nucleus and the cloudy stratum, which were first described by Mr. Dawes.

In October 1866, Mr. Lockyer, who had independently made similar observations, presented a paper to the Royal Society. He observed the lines to be thicker where they crossed a spot.

It was not until April 15, 1868, that a favourable opportunity occurred to observe the spectrum of a spot with the powerful spectroscope described in this paper. The spectroscope was rotated until the length of the slit was in the direction of the length of the spot. When the middle of the umbra was brought upon the slit, its spectrum appeared as a feebly illuminated band upon the bright solar spectrum. The band appeared divided into two parts by the spectrum of the bright prominence, which at the time extended nearly across the umbra. It was obvious that a part only of the light which appeared to form the spectrum of the umbra came from that region of the sun. The imperfect transparency of our atmosphere causes it to become strongly illuminated when the sun shines upon the earth; and the brilliant light which is seen to be radiated by it near the sun's limb is also radiated by that part of the atmosphere which is between the observer and the sun.

In order to determine how much of the light came from the atmosphere, I made use of a graduated wedge of neutral-tint glass, which was first interposed before the eye when the atmosphere near the limb was upon the slit. The wedge was moved until the lines ceased to be distinguishable. When the umbra was upon the slit, the wedge was again moved so as to bring the same part of the spectrum to the same degree of obscurity, as nearly as could be judged by the inability of the eye to distinguish the lines. In this way it was found that, roughly, about three-fourths of the light which formed the spectrum of the umbra was really due to that part of the sun.

As, in consequence of the way in which the spectrum is formed, under similar instrumental conditions the dark lines should appear rather thicker

when the light is feeble, the lines as they appeared in the still feebler light of the atmosphere near the sun's edge were carefully compared with the same lines in the spectrum of the umbra. The lines in the former case, though they appeared slightly stronger, were not so in a degree that could be accepted as an explanation of the more marked increase of strength which they presented in the spectrum of the umbra. There seemed, therefore, to be evidence of a peculiarity due to the light of the umbra itself.

In the spectrum of the umbra, which was sufficiently extended to show all the lines in Kirchhoff's maps, no lines were detected which were not also present in the spectrum of the sun's normal surface, nor were any lines observed to be wanting.

The increase of thickness did not take place in the same proportion for all the lines. The lines C and F, due to hydrogen, appeared to be increased but in a very small degree, not more so than would be due to the feebler intensity of the light.

There is a small group of lines a little less refrangible than *b*, at 1601 to 1609 of Kirchhoff's scale, and which in his map are marked as coincident with chromium, which were increased in a very marked degree. The lines D appeared in a small degree broader, as if by the addition of a faint and narrow nebulosity at both edges (see fig. 3. Pl. V.). The group of lines at B was stronger, also the lines *b* and E and many lines found by Kirchhoff to be coincident with lines of iron. The absence of sensible increase in F was marked, in comparison with the greater strength of a line or lines, on the less refrangible side of F, at about 2066·2 to 2067·1 of Kirchhoff's scale.

No *bright* lines were detected in the spectrum of the umbra.

It may be permitted to refer to some of the conditions of the solar surface by which the phenomena observed might be brought about*.

A cooler state of the heated vapours by which the dark lines of the solar spectrum are produced would diminish the radiation from the gas itself, and thus leave more completely uncompensated the absorption by the gas of the light from behind it. Such a cause would produce increased blackness of the lines, but would not account for more than a very slight apparent increase of breadth. The greater breadth of the lines may point to a condition of the solar vapours in which their power of absorption embraces, for each line, a greater range of wave-length. Such an alteration we know to occur in hydrogen as its tension increases. It may therefore be due to an increase of the density of the vapours existing within the umbra.

We do not know from how a great a depth below the layer of bright granules the light came that we have now under consideration. Probably it was emitted, for the most part, by that part of the sun which Mr. Dawes has named the cloudy stratum.

We have at present no certain knowledge of the true nature of a solar spot. Telescopic observation would seem to suggest that it consists essentially of the unveiling, by the withdrawal and dissipation of the layer of bright granules, of that part of the sun which is immediately beneath the granules, and of which we obtain some glimpses through the *pores*, which are always present, and are of different degrees of blackness.

The absence of bright lines from the spectrum of the umbra may show that no considerable part of the light which emanates from the umbra of a spot is due to luminous gas. This negative evidence, however, is probably

* [The absence of increase in the lines C and F may show that the absorption by hydrogen is not materially increased, or it may be caused by the bright lines of prominences lying over the umbra of the spot.—January 1869.]

not sufficient to support the conclusion that no part of the light of the umbra is from such a source. The luminous gas would emit light of the same refrangibility as some of the dark lines of the solar spectrum. If these existed above the same substance in a cooler state, the light might be absorbed, and the feebler emanations of the still luminous but cooler vapours might not do more than render less intense the dark gaps produced by the vapours on the stronger light of all refrangibilities which is also present. What may be the source of this light we do not know. It is not impossible that the dense and intensely heated gases which probably form the inner substance of the sun may in some cases emit lines so greatly expanded as to form, when numerous spectra are superposed, a sensibly continuous spectrum. Gases, when dense, appear to give a continuous spectrum, in addition to that consisting of bright lines.

§ V. Observations of the Planets.

Mars.—In a paper presented to the Royal Astronomical Society in March 1867*, I gave the results of a further examination of the spectrum of Mars. In that paper I describe more fully than in my former papers the lines in the spectrum of this planet, which show the existence of an atmosphere similar to that of the earth, though probably not identical with it.

I give reasons which appear to show that the distinctive ruddy colour of the planet is not to be attributed to the absorptive properties of its atmosphere, but to some peculiarity which attaches to certain parts of its surface.

Neptune.—I have several times observed the spectrum of Neptune, but failed to detect any very marked lines of absorption which might account for the blue colour of the planet. The faintness of its spectrum does not permit any great value to be attached to this negative result.

On Stellar Spectrometry. *By* Padre Secchi †.

Fraunhofer was the first to analyze with the prism the light of some of the stars. He discovered in them lines analogous to those which he had discovered in the solar spectrum. Donati, an Italian astronomer now at Florence, resumed these researches and extended their field. Several astronomers followed, and amongst them the distinguished Mr. Huggins, to whom we owe a description of the spectra of a great number of stars and the application of the principle of determining the substances contained in a star from the black lines of absorption which we see in its spectrum, as was proposed by Kirchhoff. Mr. Huggins also made the wonderful discovery of the gaseous state of the nebulæ.

The field opened by these discoveries was immense, and even before the date of Mr. Huggins's publications I tried to glean some ears in it. In the first stage of these studies the principal stars only were examined, the imperfection of my instruments not allowing the examination of all the heavenly bodies.

An optical combination which I had the good fortune to discover, enabled me to extend the researches to the whole of the visible stars, and even to several telescopic ones, which present perhaps the greatest mysteries of this kind.

* Monthly Notices of the Royal Astronomical Society, vol. xxvii. p. 178.

† A communication ordered to be printed *in extenso*.

This optical combination consists of a single prism of that kind which is used for direct vision, combined with a cylindrical lens. This combination allows us to employ the full light of the stars, not diminished as in common spectroscopes by absorption, or by a slit and the several surfaces and thicknesses through which the light must pass. The image of the star in this system is formed in the focus as a luminous line of white colour if there is no prism; and with the prism the image is decomposed into a series of luminous lines arranged according to their refrangibilities, the interruptions due to the discontinuity of the light appearing as black lines.

In such a spectrum the relative position of the lines can be measured with a common screw-micrometer; and their absolute position can be determined by comparison with fundamental stars, whose lines, on account of their intensity, can be fixed in an absolute manner relatively to known substances by a common slit-spectroscope. The comparison and measurement are rendered more easy by an improvement introduced in the instrument, by means of which I can see the direct image of the star together with its spectrum. The superposition of this image on a spectral line in a part of the field of the telescope, marked by a wire, is susceptible of great nicety in measurement, and gives very accurate results.

This, in a few words, was the apparatus employed in my researches. This year I have made a considerable improvement by employing an eyepiece made with cylindrical lenses only; with these such an intensity of light is obtained that I have been able to observe the spectra of stars of the seventh and eighth magnitudes, which are of course quite invisible to the naked eye.

Let us come now to the results. Many hundred stars of every magnitude to the sixth were passed in review. A catalogue of the chief of them has been made, and partly published. The work of the last year, yet unpublished, has been especially the examination of the red stars of smaller magnitudes, of which a particular research was instituted, but which was superseded after the reception of the catalogue of Prof. Schjelerup. All the objects contained in this catalogue (printed also in Chambers's Treatise on Astronomy) have been examined to the eighth magnitude, beyond which limit my instrument cannot give a good spectrum.

The principal results and conclusions at which I have arrived are these:—

1st. All the stars in relation to their spectrum can be divided into four groups, for each of which the type of spectrum is quite different.

The first type is represented by the stars Sirius, and Vega or α Lyræ, and by all the *white* stars, as α Aquilæ, Regulus, Castor, the large stars in the Great Bear, α excepted, &c. The spectra of all these stars consist of an almost uniform prismatic series of colours, interrupted only by four very strong black lines. Of these black lines the one in the red is coincident with the solar line C of Fraunhofer: another, in the blue, coincides with the line F; the other two are also in the sun's spectrum, but they have no prominent place. These lines all belong to hydrogen gas; and the coincidence of these four black lines with those of the gas has been, by careful experiments, already proved by Mr. Huggins, and also lately by myself. In α Lyræ the coincidence is found to be perfectly accurate. Mr. Huggins, however, finds a little difference in the spectrum of Sirius, for which we may account in another way, as I will explain presently.

Stars of this first type are very numerous, and embrace almost one-half of the visible stars of the heavens. We observe, however, some difference in individual stars; so that in some the lines are broader, and in others narrower; this may be due to the thickness of the stratum which has been traversed by the luminous rays. The more vivid stars have other very fine

lines occasionally visible, but which are not characteristic of the type-form. In this type the red rays are very faint in proportion to the blue, violet, and green, so that the colour of the star tends to the blue hue, and occasionally to the green. Of this last kind is the group of the large constellation Orion and its neighbourhood.

The second type is that of the yellow stars, as Capella, Pollux, Arcturus, Aldebaran, α Ursæ Majoris, &c. These stars have a spectrum exactly like that of our sun—that is, distinguished by very fine and numerous lines. These stars give occasionally a continuous spectrum, when the state of the atmosphere is not good; but in general the lines may be distinguished very easily. A fuller description is unnecessary, since the spectrum of the sun is very well known. The only thing which deserves particular attention is that in this class occasionally the magnesium lines are very strong, so as to produce very strong bands, and the iron lines in the green are in some very distinct. These stars can be distinguished even without the prism by the difference of colour, a rich yellow, which contrasts strongly with that of the first type. Stars of this second type are very numerous, and embrace almost the other half of the stars.

The third and very remarkable type is that of orange or reddish stars. These have as a prototype the stars α Herculis, α Orionis, Antares, o Ceti, β Pegasi. The spectra of these stars show a row of columns at least eight in number, which are formed by strong luminous bands alternating with darker ones, so arranged as to represent apparently a series of round pillars, closely resembling a colonnade. α Herculis is exceedingly remarkable in this respect; the other stars are more or less clearly divided into pillars; but it is quite impossible to describe the beauty of the appearance which is visible in a telescope on a fine night.

All the pillars are generally resolved more or less completely in different stars into smaller and finer lines, very sharp and clear. I have carefully drawn, after actual measurements, the spectrum of α Orionis and α Herculis; and in my memoir those of Antares and Aldebaran are given. In these stars some of the divisions of the pillars correspond to some principal lines of Fraunhofer, as D and b; but others, although very near, do not coincide with them, as C and F. The presence of hydrogen, however, is certain, the lines C and F having been found in the principal of them.

The divisions of the pillars after many measurements have been found to agree perfectly in all these stars; so that this type is very constant and well marked. In my catalogue 25 of these most interesting objects are registered; and I do not imagine that I have exhausted the number.

A very interesting feature connects this type with the preceding one. Here I must remark that we have to distinguish between lines and bands of shadow. The lines are strips narrow and sharp, the bands are shaded; although perhaps each band may be composed of very small lines, the aspect with our instruments (as at present constructed) is that of a more or less continuous shade. This shade is analogous to that which is produced by the vapour of our atmosphere in the spectrum of the sun when it is near the horizon.

Now it is a very remarkable fact that these types seem to differ from one another not in the metallic lines, but in the nebulous bands. Thus, for instance, the spectrum of Arcturus and Aldebaran represent the same metallic lines as α Orionis, but this has bands in addition; the feature, however, is altogether so peculiar that a different type must be constituted. It is to be remarked also that all the pillars have their luminous sides toward the red,

while the shadowed sides are towards the violet; this difference is very substantial, as we shall see presently.

The following is a list of the most remarkable stars of this type:—

o Ceti	Nova	234
α Ceti	137	254
ρ Persei	160	*β* Pegasi
Schjel. 44	162	266
45	Arcturus	267
59	Schjel. 178	*α* Idræ
Orionis	Antares	*δ* Virginis
67	*α* Herculis	
120	Nova	

(Their positions can be obtained from Chambers's 'Astronomy.')

The fourth type is not less remarkable. This is the result of a laborious research on the telescopic stars of a red colour. Some of these are very small; and none of them exceed the sixth magnitude. This is the reason why in my first memoir I limited the spectra to three types only, being engaged on larger stars only. The spectrum of this type consists of three large bands of light, which alternate with dark spaces so distributed as to have the most luminous side towards the violet.

A very fine prototype of this is seen in the small star of the Great Bear, of the position R.A. $=12^{h}\ 38^{m}{\cdot}5$, Decl. $=46°\ 15'$ N. But occasionally there are in the yellow and red numerous interruptions, which divide these large luminous spaces into smaller ones, as in the stars R.A. $=22^{h}\ 52^{m}{\cdot}5$, Decl. $=-25°51'$, and R.A. $=6^{h}\ 26^{m}{\cdot}9$, Decl. $=38°\ 33'$. A great part of the red stars of the catalogue of Lalande, and of that of M. Schjelerup, belong to this or the preceding type; of this last class I have found seventeen remarkable examples. The characteristic colour here also may be a guide in the research, since some of these are like drops of blood in the field of the telescope. It is to be noticed that the line of magnesium *b* falls almost exactly at the end of the second luminous band in the green; but the full aspect of the spectrum does not justify the presence of such metal, but rather of a gas like carbon, which has luminous bands corresponding almost to the dark ones of the star, but not exactly.

I do not attempt, however, to fix the nature of the substances, since I have not yet made a sufficient number of comparative measurements; but it seems to me that we are authorized in supposing these stars to be still in a different condition from others, perhaps partly in the gaseous state, or at least surrounded by a very large atmosphere different certainly from that of the others.

The following is a Catalogue of these Stars of the fourth type.

No. in the Catalogue of Schjelerup.	Right Ascension.	Declination.	Magnitude.	Remarks.	No. in the Catalogue of Schjelerup.	Right Ascension.	Declination.	Magnitude.	Remarks.
	h m	° ′				h m	° ′		
41	4 36·2	+ 67 54	6^a	Fine.	152	12 38·5	+ 46 15	6^a	Superb.
43	4 42·8	+ 28 16	8^a		159	13 19·3	− 11 59	$5^a\frac{1}{2}$	
51	4 58·1	+ 0 59	6^a		163	13 47·3	+ 41 2	7^a	
78	6 26·9	+ 38 33	$6^a\frac{1}{2}$	Fine.	229	19 26·5	+ 76 17	$6^a\frac{1}{2}$	
89	7 11·5	− 11 43	$7^a\frac{1}{2}$		238	20 8·6	− 21 45	6^a	
124	9 44·6	− 22 22	$6^a\frac{1}{2}$		249	21 25·8	+ 50 58	9^a	
128	10 5·8	− 34 38	7^a		252	21 38·6	+ 37 13	$8^a\frac{1}{2}$	
132	10 30·7	− 12 39	6^a	Fine.	273	23 39·2	+ 2 42	6^a	Fine.
136	10 44·8	− 20 30	$6^a\frac{1}{2}$		276	22 52·5	− 25 51	6^a	Very fine.

The most striking object for its singularity which I have met in this examination of the heavens, and which is quite unique, with the exception of a very faint companion, is γ Cassiopeiæ. This star showed to me for the first time the lines of hydrogen in a luminous state, exactly the reverse of the dark lines of the stars of the first type. The star β Lyræ has the same feature, but in a very faint degree.

We have therefore, without doubt, in the heavens a grand fact, the fundamental distinction between the stars according to a small number of types; this opens a field for very many important cosmological speculations.

2. Another grand fact which was brought out from these researches was, that the stars of the same type are occasionally crowded in the same space of the heavens. Thus the white stars are thickly gathered in Leo, in Ursa Major, in Lyra, Pleiades, &c., while the yellow ones are very frequent in Cetus, in Eridanus, Hydra, &c. The region of Orion is very remarkable for having all over and in its neighbourhood green stars of the first type, but with very narrow lines and with scarcely any red colour. It seems that this particular kind of star is seen through the great mass which constitutes the great nebula of Orion, whose spectrum may contrast with the primitive spectrum of the stars. Sirius is perhaps too near us to be affected by this influence.

This distribution of stars seems to indicate in space a particular distribution of matter or of temperature in different regions.

3. A third very remarkable conclusion arrived at is, that all the spectra of the third and fourth type belong to variable stars. The representative of these is the *wonderful* star Mira Ceti. This has been carefully examined; and it is found that even when it is only of the seventh magnitude it has the same typical spectrum, only reduced to its few bright columns. α Orionis is in the same condition. α Tauri (or Aldebaran) and Arcturus this year appeared to be smaller and of a more red hue than in the past year; and in the first there appeared traces of columns which were not seen the year before; so that it is evident that the change of these stars depends on a periodical change which happens in their atmospheres.

It is not so, however, with Algol, which has the very same spectrum of the first class or type in every stage of magnitude, which induces me to believe that there the variation is produced by the passage of an opaque body passing between it and the central star, giving thus an example of eclipse of a fixed star by its own obscure planet.

4. Finally, a very delicate question was proposed by myself, to be resolved by spectrum analysis; this consists in ascertaining whether the star has a proper motion, by the displacement of the lines which ought to take place in the spectrum owing to the combined motion of the star and the propagation of light. From this new kind of observation it would be easy to ascertain if a star has a motion whose velocity is five times that of our earth around the sun. The star α Lyræ, examined in this manner, has not given any such displacement; so that it appears not to have such a motion. In some other stars I have found that there is a little displacement, as in ϵ Ursæ Majoris; but this seems especially due to the different breadth of the hydrogen line in the star and in the chemical spectrum. I have used in this investigation the comparison of the direct image of a star with its own spectrum, but I have found no appreciable displacement. My first researches of this kind commenced with the supposition that in Sirius there was a perfect coincidence of the lines of hydrogen with those of the star. Now I am told that your distinguished countryman, Mr. Huggins, has found a little dif-

ference for Sirius. As his experience in making such comparisons is greater than mine, I leave to him the solution of this question, satisfied that the first proposal of this method for determining the proper motion of the stars, which I made in 1863, has been well received by such a competent judge.

I will conclude with a few words on the nebulæ, and especially on that of Orion. I have the honour to exhibit a drawing of it, made with every care; it is intended to show how far we may see with a single $9\frac{1}{2}$-inch object-glass, leaving to your gigantic instruments to penetrate more deeply into these wonderful objects. I shall only say that on the other side of the galaxy I have examined several nebulæ, and found them to have the same spectrum as θ Orionis. A difficulty, however, arose in my mind about this subject, which is as follows:—How can it be that while hydrogen gas has so fine and rich a spectrum, we do not see in the nebulæ anything except the simple line F? I undertook, therefore, a kind of photometrical discussion of the intensity of luminosity of the different lines which constitute the spectrum of this substance; and the result is that, in diminishing the light by an absorbing screen and simple reflections, we could reduce the spectrum to a single line F, as we see it in the nebulæ. Even hydrogen burning at the ordinary temperature has not given any line besides this after reflection. The difficulty is therefore completely removed, being only a question of intensity of light.

Here you see that the matter is not exhausted. We want yet to make a more thorough review of our discoveries to settle many doubtful points. It is for the chemical philosopher to resolve some of these difficulties, the astronomer can walk here only with the lamp of chemistry. We have already had great satisfaction in seeing quite lately that the brilliancy of a comet was due to the rays of carbon*. Ere long we shall more accurately know what maintains light and heat in so many bodies which are scattered in the profundity of space.

Report on the Physiological Action of the Methyl and allied Compounds. By Benjamin W. Richardson, *M.A., M.D., F.R.S.*

During the past twelve months, in accordance with the request of the Association, I have continued my researches on the physiological action of the methyl compounds and their allies. I have had in this research four objects in view:—

1. To bring into actual practice as remedies some of the substances the physiological action of which I had already ascertained, and on which I had previously reported.
2. To examine further the special mode of action of those bodies of the series which will produce sleep and insensibility to pain—the anæsthetics of the series.
3. To investigate the action of some other bodies of the series, which have not as yet been studied by the physiologist, in relation to anæsthesia.
4. To test the antidotal influence of some of the compounds against the action of certain active alkaloidal poisons.

To render the Report systematic, I shall place the subject-matter under the heads above named.

* The discovery of the lines of carbon was made by the author and communicated to the French Academy while Mr. Huggins was independently discovering the same thing.

PART I.—ON THE PRACTICAL APPLICATION OF CERTAIN OF THE SUBSTANCES BROUGHT FORWARD OR DESCRIBED IN PREVIOUS REPORTS.

Bichloride of Methylene.

In my last Report I described that the bichloride of methylene, $C H_2 Cl_2$, was an excellent anæsthetic substance, and for many reasons preferable to chloroform. I have since confirmed this view fully by practice. After subjecting myself to the action of the vapour to the production of perfect insensibility, I ventured to administer it for surgical purposes on the 15th of October last. The sleep produced was of the deepest and gentlest character, and the operation, performed by Mr. Spencer Wells, and which lasted 35 minutes, was quite painless. One trifling difficulty only stood in the way: the air of the room being warm, and the fluid having a low boiling-point, the water from the breath of the patient, with which the inhaler was saturated, became frozen, and was somewhat troublesome to use. This difficulty was soon met by the invention of a new form of inhaler, exhibited to the Section. This inhaler answers, not only for the administration of bichloride of methylene, but for all fluids which boil at a low temperature and are useful for inhalation.

The instrument is constructed in such manner that the fluid can be conveyed, grain by grain, and distributed in the form of spray on a surface of thin flannel, spread over a mouthpiece made of vulcanite.

Bichloride of methylene differs from chloroform in action in several particulars. The anæsthetic sleep is produced more quickly, and when produced is more prolonged. On the other hand, recovery, when it commences, is far more rapid; indeed the period of recovery, according to my experience, is never extended over four minutes, and there are no prolonged or painful after-effects.

When animals are allowed to sleep to death in vapour of bichloride of methylene, the lungs are found containing blood, but not congested, while the heart contains blood on both sides. In this respect the vapour acts differently from both chloroform and ether. After death in chloroform-vapour the lungs are left bloodless, and the right side of the heart gorged with blood. After death from vapour of ether the lungs are left intensely congested, with the heart containing blood on both sides.

Bichloride of methylene holds a place between ether and chloroform. It is safer than chloroform, but not so safe as ether. In matter of efficiency of action it is equal to chloroform, while it is quicker in action, and more persistent, and far more manageable than ether.

Bichloride of methylene has been largely used by other observers during the past year. Reports of its employment have reached me from New York, Paris, Hanover, and other parts of Germany, from Australia, and from different towns in England. These reports are unexceptionally good, and no fatal accident has as yet befallen the administration.

There is, however, as yet one drawback to its general introduction; I mean the difficulty of manufacturing it on a large scale at a reasonable cost. It is also, when pure, more difficult to keep than chloroform, its boiling-point being at least 33 degrees lower on Fahrenheit's scale (18°·3 C.).

The question of the exact composition of the bichloride of methylene has been recently determined from analysis by one of our best organic chemists, Mr. Perkin, who has confirmed the composition as $C H_2 Cl_2$. He has, however, made a correction of the boiling-point, which he places at 104° F. (40° C.).

This is 16° F. (8°·8 C.) higher than has been given to it by other observers, as well as by myself. Quite independently I had also detected this error, which has arisen, I doubt not, from the presence, in the earlier specimens of the fluid, of a little chloride of methyl. I think that even yet there is some slight cause of error, and that the boiling-point is actually 111° F. (43°·8 C.).

The difficulty of manufacturing bichloride of methylene in sufficient quantities at a reasonable cost is, I repeat, the only objection to its more general employment. In quantities of two or three ounces the manufacture is easy; but the distillation at a low temperature, which is required, renders the process tedious on a large scale, and therefore expensive. The difficulties, I trust, will in time be overcome.

Nitrite of Amyl.

In my first Report on nitrite of amyl I suggested its employment by inhalation in cases of acute spasmodic disease, as in tetanus. I reported last year that the nitrite had, at the instance of Dr. Brunton, been used for the treatment of one of the most painful spasmodic complaints; I mean cardiac apnœa, or, as it was formerly called, angina pectoris. The practice continues to be followed, and the effect has been remarkable for good: the paroxysm of angina is often relieved with almost instant action; and from experience of the value of this ready means of giving breath to persons whose chests are for a moment immoveably fixed it is becoming widely applied. I have seen myself the happiest results from this method, and I have therefore given attention to the details of the administration, so as to render it safe. In my last Report I mentioned ether as a solvent; but on testing the solubility of the nitrite and the solutions which give it up most steadily, I find nothing to answer so well as absolute alcohol. The best solution is one containing ten parts of the nitrite in 500 of alcohol. Practically, and for easy remembrance, 50 minims of the nitrite to 1 fluid ounce of the alcohol may be considered a proper mixture. I exhibited this compound; and it will be found even agreeable as a fluid for inhalation. In using it not more than two fluid drachms should be applied at once. The fluid should be poured upon a handkerchief arranged in the shape of a funnel, or into a funnel of paper, and the vapour should be inhaled gently.

I dwell on the necessity of using this dilute alcoholic solution, because the nitrite of amyl, in its pure state, is one of the most potent of agents. In one instance, as I have before recorded, a friend of mine, by inhaling it incautiously, nearly destroyed himself. It is, in fact, as quick to kill, by the sudden paralysis of the blood-vessels which it induces, as it is to relieve muscles of spasm.

Nitrite of amyl has been used in the later stages of cholera by Dr. Hayden, of Dublin. I recorded this fact last year at Dundee. Happily we have had no occasion to test the virtue of the remedy further in this direction during the past twelve months.

Iodide of Methyl.

Iodide of methyl, briefly noticed in my last Report, has come into very important use during the past year. I showed at Dundee that it was an agent which could be made, by careful inhalation, to produce anæsthesia, but that it was very difficult to manage in the form of vapour. Its remarkable sedative effect led me to study its influence when administered by the mouth, and I commenced to learn the dose that could be borne by taking it myself, in solution with alcohol. I found that a grain could be taken with perfect

safety. I then prescribed it in an inveterate case of specific ulceration, in which iodide of potassium had failed, and, carrying the dose up to three grains, found the most rapid curative result. Further, the great pain and irritability of the ulcerated surfaces was singularly relieved. Repeating this observation with further success, I solicited permission of Mr. Nunn to treat some hopeless cases of cancerous ulcer in the cancer wards of the Middlesex Hospital. Four cases were assigned to me, and the suggested plan was carried out by Mr. Nunn himself. His report of the results, after four months' trial, is of the most encouraging character. One case of ulceration is reported as healed so that the patient has left the hospital; another, in which there was intense hyperæsthesia (extreme sensibility of skin), a symptom which had resisted all previous means, was directly relieved, and the patient has greatly improved. In a third example pain of an extreme kind was relieved; and in the fourth the symptoms remain in abeyance. Mr. Nunn concludes by stating that his observations show the iodide of methyl can be safely administered for long periods of time, that it removes pain, particularly that form of pain called hyperæsthesia, and that cancerous ulceration may heal under its use. He is not, however, prepared to say that it will prevent the deposit of cancer.

I put before the Section a solution of the iodide as it is ready for use. The solution contains 6 grains of the iodide in 60° of alcohol. The quantity to begin with is 10 minims in water. It is agreeable to take.

The same solution can be administered by inhalation.

PART II.—AN ANALYSIS OF VARIOUS PHENOMENA CONNECTED WITH THE ACTION OF CERTAIN OF THE METHYL AND ETHYL COMPOUNDS.

There are certain of the compounds of the methyl and ethyl series which possess the common property of producing sleep and the insensibility of living organisms. This general fact seems at first sight to link them all together; and in regard to the one fact they are closely united. But there are, notwithstanding, points of difference of the most important character. For example, they all sometimes kill during their administration, but they are not all equally powerful to kill. This alone is sufficient to distinguish them; and as from them we derive those agencies by which some hundred thousands of our kindred are each year relieved of pain with some risk of life, I have thought it of moment to study the differences of phenomena presented by different agents, so that we may be able to approach to a knowledge of first principles, and seize all the real good, with avoidance of what at this moment appears an inevitable degree of evil.

As it was impossible to investigate all the bodies of the series, I confined my research to a few representatives only; and, indeed, what has been gathered in this way is too long to be recorded in anything but abstract.

Physical Changes of Blood produced by different Methyl and Ethyl Compounds.

When a man or an inferior animal is subjected to one of the ordinary anæsthetics, great difference is observed in the change of colour of the blood, the difference itself being determined by the class of agent that is being used. Under the influence of all the chlorides, of both the methyl and ethyl series, the blood retains its bright-red colour on the arterial side, while on the venous side the colour is slightly heightened. Under the influence of the oxides of the methyl and ethyl series the reverse obtains; the arterial

blood is rendered dark in colour, and the venous blood is made darker than is natural.

When these fluids are added to blood freshly drawn, these same changes are also observed, together with a difference in the period of coagulation, the process of coagulation being quickened by the chlorides, and slightly retarded by the oxides. In the blood of some animals, such as the sheep and the common fowl, the period of natural coagulation is so rapid that the difference is not easily computed; but the blood of the ox, which at the temperature of 60° F. (15·5 C.) coagulates normally in three minutes, shows the fact clearly, ten per cent. of chloroform quickening the coagulation a full minute and a half, while the same proportion of ether delays it an interval of two minutes beyond the normal period.

When the different agents are added to defibrinated fresh blood in the proportion of five per cent., the most striking differences are observed in respect to colour, fluidity, change in the corpuscles, and development of blood-crystals. In investigating these changes, I subjected equal quantities of freshly defibrinated sheep's blood to representatives of the methyl and ethyl series, and set them aside for observation during a period of thirty-five days. They were examined carefully on the first and thirty-fifth day, as well as on intervening days, by my friend Dr. Sedgwick, who was so good as to relieve me greatly of this labour, and who has condensed the record of the changes as they were observed to occur stage by stage in the course of the inquiry.

Bichloride of Methylene.—On addition of the bichloride of methylene to blood, the colour was rendered bright and full red; and this colour was maintained until the thirty-fifth day. The blood remained fluid throughout. The red corpuscles commenced to dissolve on the first day, and by the thirty-fifth day scarcely a corpuscle was left. Blood-crystals were at no time developed; but plates and masses undefined in shape were observed to form on the last days of observation.

Chloroform.—On the addition of the chloroform the colour of the blood became of a dark red; but it grew lighter in course of time, and remained light. The blood became of thicker consistency, and at last gelatinous. The corpuscles commenced to undergo solution at once, and on the thirty-fifth day had all disappeared. No blood-crystals were found.

Tetrachloride of Carbon.—The changes were identical in blood charged with the tetrachloride with those in blood charged with chloroform.

Methylic Alcohol.—The blood retained its natural colour throughout. The fluidity remained unchanged. The corpuscles remained the same. On the thirty-fifth day a few octahedral crystals were present.

Acetate of Methyl.—The blood was rendered at once dark. On the first day the blood was thickened; but it became thin afterwards, and remained so. The corpuscles were unchanged. No crystals.

Bromide of Methyl.—Blood became at once dark, and changed to dark-brown, which colour it retained. On the first day the corpuscles remained unchanged, but soon began to dissolve, and on the thirty-fifth day all were dissolved. No crystals.

Methylal.—Blood at once became dark, and changed to dark-brown. The blood maintained its fluidity at first; but it began to grow thick, and at last was semisolid. The corpuscles were at no time dissolved, but from the first were irregular in outline and serrated. No crystals.

Ethylic Ether.—Blood at once became dark, and remained so. Fluidity was maintained. The blood-corpuscles were perfect throughout. No crystals.

In all the specimens the blood remained free from any putrefactive change.

Influence on the Circulation and Respiration.

I have studied as a special point the influence of certain of the ethyls and methyls, with a view to determine the all-important subject of their relative action, upon the respiration and the circulation. On this point there has been long controversy—the most accepted rule being that chloroform always kills by paralyzing the heart, while ether is free from that danger. It must be confessed that at first sight this view seems to be in accordance with the general facts of observation; but a long and careful watching, in which experiment succeeds experiment, leads in time to this certain truth, that chloroform does not always kill by paralyzing the heart, but that with chloroform, as with ether, the heart will continue to beat after the respiration has ceased. The rule, therefore, is not general; the question is how far it is at all true.

To test this, I proceeded first to see whether the heart could be sustained in its action while respiration, with an atmosphere containing a narcotizing dose of chloroform, was artificially supplied. I found in this experiment no difficulty whatever, and no remaining doubt after it. A ┬-shaped tube having been inserted into the trachea of a strong animal (a dog) narcotized with vapour of chloroform, the animal was made still to breathe air charged with the vapour, in steadily increasing dose, until some change occurred. During this time, in the deadest silence from all other motions, the sounds of the heart were listened to, with the double stethoscope, by myself, while an assistant watched for the cessation of respiration. "The respiration stops" was the report; but I could still hear, not only the motion of the heart, but both the sounds in due order of time. Then the first sound began to fail, and soon the second. At this moment, on a signal from me, artificial respiration, with the same chloroform atmosphere in which the animal had gone to sleep, was set up by means of double-acting bellows; and at once, as the air filled the lung, the blood made its way again through the heart, the motion of the heart returned, the sounds returned, and the general signs of life returned. Once more the experiment was tried, and once again with the same result; and so decided was the experiment that, on giving it fresh air artificially, the animal recovered, in the end, as from simple sleep.

In a further instance I repeated the famous experiment first performed by Hook, with the difference that the animal throughout was held insensible by chloroform. In this case, after insensibility was complete, and respiration, which for some minutes had been carried on through the tracheal tube, had ceased, the heart was directly exposed to view, together with the lungs. The heart was pulsating vigorously on both sides, the lungs generally were blanched, from the blood ceasing to make its way by the pulmonary circuit: but artificial respiration of the chloroform atmosphere was reestablished; and as the lungs filled with the air the right side of the heart was set at liberty, the blood passed over the pulmonary circuit, and on withdrawing the chloroform, and for a brief period supplying the air pure, the general signs of life began to reappear. They were, of course, suppressed by repeating the chloroform; but before the heart was finally stopped in its action, the fact of being able to call it again into play by reinducing respiration was several times demonstrated.

Taking a very important practical hint from Dr. M'Intosh, who read an admirable paper at Dundee before this Section, I followed up my research by watching the circulation and respiration in young transparent trout while they were being subjected to the action of methyl and ethyl compounds. I was so fortunate at the close of last year as to be able to obtain

young trout in quantity, and so secure a very good inquiry. I hoped at first to be able to see the motion of the heart on a screen, by placing the animals in a trough in the oxyhydrogen lantern; and I have to thank Mr. Pepper and the Managers of the Royal Polytechnic Institution very heartily for placing their very perfect optical chamber at my service. I could not, however, carry out in this way all I desired; for when the figure of the animal was projected on the screen, there were no visible movements except those of respiration. I therefore turned to the microscope, and found here all I could require. To carry out my plan properly, Dr. Sedgwick was so good as to devise for me a little trough, in which the trout could be placed for observation, and through which water charged with the required compound could be passed in a steady stream. This plan prevented the accumulation of carbonic acid; and when no foreign substance was introduced into the current, the circulation and respiration of the fish could be observed for long periods naturally.

Thus provided, three substances from one series were made to act upon the trout, viz. chloroform, ether, and chloride of methyl. The observations were most interesting, but to give them in detail would be too long; I shall therefore only offer the results in an abstract, which Dr. Sedgwick, who had the observations daily before him for several weeks, has been good enough to draw out for me.

When chloroform is added to the water in which the young trout is living, in amount sufficient to destroy life in half a minute, the heart ceases acting at once, stops in diastole, full of blood. The gill and blood respiratory routine continue some little time afterwards. No contraction of extreme vessels is noticeable for some time after death. If the chloroform be added in smaller quantities, the first effect is violent struggling, which by degrees subsides. The respiration is at first much quickened, then becomes slower, and finally ceases—that is, so far as the gill, fin, and jaw motion is concerned. The heart at first beats quickly, then slowly, after a time intermits, and then totally ceases to act. No contractions of minute vessels could be observed under a power of 600 diameters. Not one of these fishes recovered from the narcotism of chloroform after the respiratory movements had ceased. With chloride-of-methyl gas in water, on the other hand, and also with ethylic ether, recovery was observed after all external respiratory movements had ceased, even for fifteen minutes, the heart beating all the time, but very slowly, the contractions reduced from 246 to 15 in a minute. The phenomena observable in these animals when narcotized with chloride of methyl is in other respects like those which occur under the use of chloroform, the notable points being the cessation of respiratory movements before the circulatory, and the absence of any definite contraction of the small vessels when the agents are administered in quantities not sufficient to produce immediate death.

These experiments prove, I think, beyond cavil, that the chlorides of the methyl series do not of necessity destroy life by their direct action upon the heart. Indeed they indicate rather that when the heart itself is sound, and the chloride is let into the system by the process of inhalation, the heart is not primarily interfered with. It was therefore all-important to learn whether the heart could be primarily arrested by making it the primary recipient of the narcotic.

To test this, a large animal was selected, and a twenty-minim dose of chloroform was slowly instilled, by one of Mr. Hunter's syringes for subcutaneous injection, into a large vein in the ear. Within a few seconds

(indeed as soon as the last minim was injected) the animal was convulsed and dead. As quickly as the operation, with every appliance at hand, could be performed, the thorax was laid open, and the lungs and heart exposed. The heart on both sides was found firmly contracted on firmly clotted blood which filled its cavities. The lungs were intensely congested with blood, also firmly coagulated, so that they cut like substance of liver; the brain was quite natural. Excited by the galvanic current, the muscles of respiration and the voluntary muscles responded well for an hour, but the heart could be roused to no sign of motion.

Here, then, we had a proof that chloroform carried directly to the heart may stop the heart primarily. In this sense, however, it does not act by paralyzing, in the ordinary sense of that word, but by exciting a vigorous contraction, prolonged to the death.

By injecting chloroform through the aorta over the whole body of an animal just dead, I saw the same sudden and permanent contraction universally developed in the muscular system.

The conclusions I have up to this time arrived at in respect to the action of chloroform and all the other chlorides of the methyl and ethyl series, are:— 1. That when these are administered by inhalation to healthy bodies, their first action, as they diffuse through the different organs, is exerted directly on the muscles, which they call into powerful contraction. 2. That this action, extending further to the arterial muscular system, suspends the influx of blood, generally leading, in return, to relaxation of the common muscles, and to arrest of cerebral function. 3. That the heart, if its coronary canals and its walls be good, lives through the catastrophe better than any other structure, and, in short, is the organ on whose power the ultimate recovery rests. 4. That death from chloroform in the healthy animal is due to failing respiratory power, and, above all, to contraction of the pulmonary artery, by which the current of blood from the right to the left side is prevented.

This view, in respect to animals, associates all the phenomena in death from chloroform; it accounts for the stage of muscular excitement, the cessation of the beat of the pulse while the heart is still beating, the continuance of the action of the heart when the respiration has stopped, and the white and bloodless condition in which the lungs are invariably discovered when death is complete.

This same view tallies moreover with all the known facts respecting sudden death under the influence of the chlorides in cases where the heart is not healthy, where, unable to live through the preliminary excitement into which, with the other muscles, it is thrown, it ceases action altogether—ceases for the same reason that it ceased in the animal when the narcotic was thrown direct into it, I mean because it is overcome by the excitation to which it is subjected. A little want of elasticity in the coronary arteries, an undue tendency to contraction in them, a deficiency of muscular substance, an interstitial deposit in the muscle,—any one of these conditions is amply sufficient to account for death from the heart under the influence of the exciting chlorides.

Under the action of the oxides of methyl and ethyl the living body avoids these dangers to a degree as yet little understood. These from the first produce very little excitability of the muscular mechanism; and when they ultimately kill, the act is not by contraction of vessels, but by slow asphyxia, the gradual extinction of oxidation from the exclusion of air.

Hence, after death by ether, the lungs are not found blanched, but congested, the heart still active, the muscles flaccid, and the blood in all the tissues dark in colour.

Influence on the Animal Temperature.

A subject of much importance seemed to me to be open for inquiry in respect to the conditions of the animal temperature under the action of those methyl and ethyl compounds which produce temporary insensibility. Attempts had already been made by myself and others to determine the order of facts from the human subject. But the circumstances under which the narcotizing agents are administered to human kind are so peculiar that no separate observer could conduct a satisfactory research in a sufficient number of cases to be reliable. To arrive at correct data, a period of three hours at least is required for each observation; the air of the room in which the observation is made must be kept at a steady and uniform heat; three observers are also wanted, and the utmost quiet must prevail, that excitement of an external character do not move or annoy the subject. To meet these necessities, I determined to conduct the research on inferior animals. I selected from two kinds of animals,—the guineapig, whose temperature is not more than two degrees above man, and the pigeon, an animal which has a mean temperature full ten degrees above that of man. I next selected chloroform and ether as the two agents to be tested; it was necessary, from the labour and time demanded, not to take more than two substances, and these I considered were fair representatives of two distinct series, while at the same time they were substances with which the world of science generally is most familiar.

I had the pleasure of being most ably assisted in observation by my friends Dr. F. Versmann and Dr. Sedgwick, with Mr. Alfred Nutt occasionally, and Mr. Alfred Haviland; in every case another pair of eyes besides my own kept strict watch. The thermometers used were by Casella. The plan of proceeding was first to bring the air of the laboratory to a fixed temperature, the mean of 54° Fahr. being carefully sustained. In this air the animal was allowed to live for two hours before the observation, and the natural temperature of the animal was carefully noted—in the pigeon from the cloaca, in the guineapig from the rectum.

The animals were put to sleep by being made gently to inhale the vapours to which they were subjected from a mask covered with thin flannel, and the thermometer was watched and registered through every stage of narcotism, and for one hour or more after recovery.

In one pigeon the observation was conducted three separate times, in another pigeon twice, and in five other pigeons once. In one guineapig the observation was made three times, in another twice, and in five others once.

The phenomena were amongst the most uniform I have ever recorded in experiment.

In the pigeons subjected to chloroform there was in every case a fall in the thermometer, during the narcotism, of from 6°·5 to 6° Fahr. This was so singularly correct that the result actually varied with the natural temperatures of the birds. Thus in one of the birds, in which the natural temperature was 107°·5, the thermometer came down regularly to 101°; while in another bird, the natural temperature of which was 110°, the thermometer regularly fell to 104°.

This decline in temperature did not date from the actual commencement of inhalation. For the first stage the thermometer remained steady; as the second stage advanced it rose on an average half a degree, to sink at once as the excitement passed away; while as the third stage was reached (with entire loss of sensation and of motion) it fell from three to four degrees. As the third stage became more determined, and the fourth approached, the decline

continued, the minimum of six degrees being marked by all the signs of impending death, viz. feeble breathing, intermittent pulse, and complete muscular relaxation. At this extreme recovery was permitted. The temperature during the recovery began in all cases to rise in from two minutes and a half to three minutes after the chloroform was withdrawn: it would even rise a degree in this period, and would continue to ascend with the same rapidity for as many as three degrees. But the last three degrees were regained always slowly, as long a time as an hour occurring for the progress of each degree; this was particularly the fact where the temperature at the beginning was very high. The bird whose temperature was 110° was three hours recovering four degrees of heat, and nine in recovering the full quantity lost, 6°. One symptom common to the action of chloroform (I mean vomiting) exerted a marked and sudden change, causing a rapid fall in the mercury of frequently two degrees. The change was not observed during the act or strain of vomiting, but instantly afterwards. The loss of heat thus sustained was not made up so long as the inhalation and the narcotism were continued.

Under ether the decline of temperature in pigeons is not so determinate as under chloroform, but it is continuous, *i. e.* without any temporary rise, from the first. The fall amounts to an average of four degrees. The absence of vomiting during administrations of ether may account for this difference to some extent; but the grand reason why the temperature keeps up so well is the quietude that prevails, the avoidance of that muscular excitement which so prominently distinguishes the action of the chlorides.

In the administration of chloroform to guineapigs the same changes of temperature were observed, but in a less marked degree. The temperature during the stage of excitement rose 1° Fahr., and then sunk three degrees, that is to say, 2° below the natural standard. The temperature also remained at the lower degree during the whole period of recovery, and did not return to the natural condition for a period of nearly four hours.

Under ether the temperature of guineapigs showed extremely slight variation. There was no preliminary increase of temperature, and under the deepest anæsthesia the reduction never reached beyond one degree and a half. The natural standard was regained within the hour.

In two short series of final experiments on temperature I inquired whether any extreme changes would result, or any differences, by artificially increasing the temperature of the air in which the animal inhaled the vapour of chloroform. A pigeon, having a natural temperature of 108° Fahr., was placed in a hot-air bath at 112° Fahr.; in a short time the temperature of the animal rose three degrees, where it remained stationary, the further accumulation of heat being arrested by copious elimination. The animal was now put to sleep with chloroform, the sleep being induced with extremest rapidity, as is common in high temperatures. During the passing interval of excitement the thermometer remained steady, and then suddenly fell to 109°. The vapour was withdrawn at this point with a return to sensibility that was startling from its rapidity. Narcotism once more induced the thermometer went down to 107°, but rose once more almost instantly to 109°, on the vapour being withdrawn.

In another observation on a pigeon, having a natural temperature of 108°, at 60° the temperature of the animal, in a room at 96°, rose to 110° Fahr. During narcotism in this state the temperature fell to 108°·5, 107°·8, 107°, and then suddenly to 105°, when insensibility was complete. As recovery progressed, the temperature rose to 108°·4, but during a slight vomiting

fell again to 107°·7. After this the temperature rose to 108°, and remained there, the animal seeming entirely well.

In a further short series of experiments the influence of cold during narcotism from ether-vapour was tested. The temperature of a pigeon having been reduced by narcotic action of ether from 107° to 104°, the spray of ether was directed upon the head until the superficies of the cerebrum were solidified. Under these combined influences the temperature of the body ran down as low as 97°·7. At this point of extreme reduction of heat there occurred a severe tremor; but on restoring warmth, the recovery was steady and good, the natural heat being back in ten hours.

In a similar experiment made with chloroform-vapour, the results were the same within a little less than a degree. The reduction of temperature was from 107°·5 to 98°·5. The recovery was good.

One other experiment deserves notice, for the accident attending it. In administering chloroform to a rabbit having a temperature of 102°, the thermometer, during a sharp paroxysm of muscular excitement, rose at one move to 103°·8, or nearly two degrees. At the moment the heart ceased to pulsate, and the animal was dead. The occurrence is entirely in character with what has often happened in the human subject under chloroform. The heart involved in the sudden muscular excitement has contracted spasmodically, and the motion of life has ceased for good.

I ought almost to apologize for relating these facts on the temperature of animals under chloroform and ether with so much minuteness; but practical physiologists, who will at once see their bearing, will pardon me. The facts we have gathered are:—

(*a*) That during the stage of the muscular excitement incident to the circulation of chloroform through the body there is a temporary increment of heat.

(*b*) That with the cessation of the muscular motion there is a gradual decrease of heat.

(*c*) That the decrease of temperature is greatly accelerated and intensified by the act of vomiting.

(*d*) That coincidently with the minimum of reduced animal temperature there is intermittent action of the heart and the extreme of muscular prostration.

Influence of Electrical Excitation during the Action of Methyl and Ethyl Compounds.

The observations already recorded led me to make a further inquiry in respect to the influence of the galvanic current at different stages of narcotism. In this research chloroform was the only narcotic used, and pigeons were the subjects of experiment.

In the first experiment, the animal having been subjected to the vapour of chloroform until the development of the stage of excitement, and the consequent increase of temperature, a needle connected with one pole of an electro-magnetic machine was passed through the skin of the neck, while a second needle was passed through the leg. The free end of the second pole was next brought to the needle in the leg, and a moderate current was passed through the body. In an instant the muscular over-action was converted into general rigidity, the chest was fixed, the heart was fixed, and death was the immediate result.

In the next experiment, the same arrangements for the transmission of the current having been made as before, and the same strength of current

being used, the other details were changed. The animal was allowed to pass through the stage of muscular excitement into the third stage of muscular relaxation. This stage reached, the current was transmitted through the body of the animal. The effect, again instantaneous, was not to destroy life, but to excite all the phenomena of apparent active life. The wings were moved as in the act of flight, motions attended with progressive or propulsive action were strongly marked, the breathing was quickened, the impulse of the heart was increased, and the temperature rose; but when the current was withdrawn all these striking phenomena were withdrawn also, and the animal again slept inactive and prostrate, but ready to recover.

For the sake of comparison another experiment of a similar character was carried out, in which, instead of reducing the animal body by the administration of chloroform, the spray of ether was directed upon the cerebrum until the phenomena of entire unconsciousness and of muscular prostration were fully pronounced. Then the current from the coil was passed through the body as before, with the temporary development of the phenomena of muscular activity.

The lessons taught by these experiments are in confirmation of all that has gone before. They prove how distinct a double action on the muscular organs is exerted by chloroform, and they indicate an independency of influence upon the muscular and nervous systems, between insensibility, or I had better say unconsciousness, and deficiency of motor power, which I was not myself, previous to the experiments, prepared to recognize. It is clear that in the narcotism induced by chloroform, and perhaps by all other similar agents, the muscles can be called into action while the brain is virtually dead; we can, in short, supply the muscles with an artificial nervous energy.

Dangers attending administration of Methyl or Ethyl Compounds.

Recasting these experiments and putting the various facts in order, I have been led to consider from them the dangers which waylay the administrators of the methyl and ethyl compounds, the causes of these dangers, and the way to avoid them.

And here, I think, is a primary truth, the basis of progress in the discovery of new agents:—that the danger in anæsthesia does not lie in the production of sleep, nor even of deep sleep, but in the production, in the course of the process, of symptoms which, although the prime sources of danger, are not connected by any necessity with the anæsthesia. I refer especially to the symptoms of muscular excitement and rigidity, followed, as we have seen, by decrease of temperature of the animal.

Again, I think there is another truth hardly secondary, viz. that we already possess agents which by their action prove to us their power of producing anæsthesia without exciting muscular rigidity, and without materially disturbing the animal temperature. If this be true, we ought as men of science to exclude at once from the list of safe anæsthetics all such as on experiment are found to produce rigidity of muscle or vomiting (which is an indication of the same action), and reduction of heat by its transference into motion at a moment when the conditions for the liberation of force are most unfavourable.

The exclusion here named would, I conceive, of itself save many lives, and would bring the danger of artificially induced sleep to the danger, and no more, of mere natural sleep. The only cause of accident would be in carrying the insensibility to the extreme of extinguishing life, an accident for which the administrator would be clearly culpable, and which, even now,

when very dangerous agents are in daily use, has never, as far as I know, happened.

In searching for the agents we require, we must begin by excluding bad ones, which is, in fact, to exclude whole classes. The class of the chlorides, under this rule, would all go. It is true they are not all equally dangerous, and that the increase of danger is in proportion to the substitution of chlorine; but, as a class, they one and all do more than we require, they produce muscular rigidity, vomiting, and decrease of animal heat. This same rule holds good in relation to the iodides and the bromides. Supposing, then, we keep to the methyl and ethyl series as bases, we are driven back to the oxides, to what are commonly the ethers, for our agents. None of these which have yet been applied have been actually perfect; but it is almost certain that in course of time the chemist will produce for the physiologist the precise requirement. That it may be generally known what this requirement is, I will state in a few sentences the theoretical formula of a safe anæsthetic, an anæsthetic that shall be applicable to long and short operations alike, and shall become acceptable generally from its readiness and safety.

1. It must be a fluid. Gases, however good, are not practicable as agents for general and daily use; more than this, as at the temperature of the blood they remain as gases, and when dissolved in blood they exert no action from change of form in the organism. To narcotize with them it is consequently necessary to give them in large quantities, even it may be to the exclusion of air altogether. The influence of a gas thus administered is of necessity limited to the briefest interval of time; steady continuance would lead to certain death from asphyxia.

2. The fluid must possess homogeny and stability. Mixtures of fluids are utterly unreliable. Fluids which easily decompose under the influence of heat or of light are unreliable.

3. The fluid must be of pleasant odour, and must produce no irritation when inhaled or when applied to the skin. All the fluids which, like chloroform, amylene, and turpentine, cause redness and irritation of skin, cause also, when introduced into the blood, irritability of muscle and rigidity, together with vomiting.

4. The boiling-point of the fluid should be not less than 110° Fahr., and not over 130°. Fluids which pass into vapour below the temperature of the animal body act practically as gases, and must be used in free quantities to the exclusion of air; common ether, amylene, and bichloride of methylene have this fault, the last least. Fluids, on the other hand, which pass altogether into vapour at a point much above the animal temperature, as at 140° or upwards, condense in the pulmonary blood too determinately, and although they create a long sleep, they remain for a considerable period in the body, creating continued nausea and depression from interference with the conservation of the animal heat. Chloroform, tetrachloride of carbon, and common alcohol are objectionable on these grounds. A fluid which should have a boiling-point some 20° above the body, and other properties equally good to commend it, would be convenient in every respect. It could be easily preserved, and as an anæsthetic it would be alike applicable to long and short operations.

5. The density of the vapour of the fluid should be about 40, taking hydrogen as unity.

In the large Table before the Section I have named a list of substances (23 in all), which have received from me the most careful investigation; they are all wanting in some property that is essential, but one or two new observations respecting the action of certain of them are worthy of notice.

On Methylic Ether in Ethylic Ether.—To obtain a very quickly acting and safe anæsthetic fluid I saturated common ether with methylic ether. A very agreeable but, of course, unstable fluid was in this way obtained. After narcotizing several animals with this compound, I allowed my friends Dr. Sedgwick and Mr. Marshall to subject me to it on the 20th of May of this year. The vapour caused no irritation, and I was, I learn from Dr. Sedgwick's note, "well off" in one minute, the pulse rising from 70 to 96. At first the respiration was slightly sobbing, two or three rapid inspirations being followed by two or three similar expirations. There was no change of colour in the face, and no coldness. After being insensible for seventy seconds, I awoke sufficiently to speak to my friends, but I do not remember the circumstance, and I am reported to have fallen off quietly to sleep again, after moving from the chair in which I was sitting to a couch, on which I lay down. Here I slept very quietly, with easy breathing, for at least two minutes, and then I awoke with slight sobbing, followed by a violent and irrepressible fit of laughter. Recovery was rapid, indeed instantaneous, after this, and was unattended by any one disagreeable symptom; there was no vomiting, no nausea, no headache; indeed in five minutes I was following my occupations as if nothing had interfered with them.

In order to see the extreme effect of methylic ether, I allowed a guinea-pig, when profoundly narcotized, to remain in an atmosphere holding 15 per cent. of the gas. The animal continued to breathe easily for nine minutes in this atmosphere, then the breathing became irregular, and at fourteen minutes it stopped. I now removed the animal into pure air at 75°, and on examining the heart I found that organ beating steadily, and with the sounds most distinct. I continued to watch for restoration of breathing, and four minutes and twenty-three seconds afterwards observed a slight movement of breathing; in two or three seconds more these movements were repeated, in another minute there were sixteen inspirations in forty-five seconds, and the animal in the end recovered rapidly and soundly, with nothing worse than a slight shivering. In this experiment there was the longest complete suspension of respiration in a warm-blooded animal I have ever seen, followed by recovery.

In a further series of experiments I allowed pigeons, rabbits, and guinea-pigs to sleep to death in methylic ether. In all cases the respiration ceased before the heart stopped its rhythmical pulsation, and in every case there was found after death slight congestion of the lungs, blood on both sides of the heart, and blood on the arterial side darkened in colour. In no case did spasmodic action precede death.

In recording the phenomena induced by the inhalation of methylic ether, we cannot but be struck with an analogous action between it and nitrous oxide or laughing-gas. Like nitrous oxide it acts quickly, and its effects quickly pass away, but it does not produce the same degree of asphyxia, and it acts when freely diluted with air.

Methylal.

Another substance which promised to be a good agent was methylal. The composition of methylal is $C_3 H_8 O_2$; its specific gravity is 0·855, and its vapour density is 38. It was made for me by Dr. F. Versmann. It is made by distilling methylic alcohol and sulphuric acid with peroxide of manganese. It is a clear fluid, boiling at 108° F., and having a sweet ethereal odour. It is soluble in water as well as in ether and alcohol.

In the vapour of methylal animals pass into sleep gently and slowly with

perfect insensibility. The peculiarity of action is slowness. When the sleep has been produced, it lasts a considerable period, and is undisturbed, but the respiration is slow and heavy. There is no marked excitement and no vomiting. If the action were less prolonged, methylal would rank amongst the best of anæsthetics. It is a very agreeable vapour to inhale.

Formiate of Ethyl.

The last agent which I tested was the formiate of ethyl. The composition of the formiate is $C_3 H_6 O_2$, the boiling-point 130°, the vapour-density 37°. It is made by distilling alcohol with formic acid. In the vapour of this substance animals fall into a stupor, but do not actually sleep. They have considerable muscular excitement, and vomiting is easily excited. The vapour is also irritating to the throat and to the air-passages of the lung.

My chief object in testing the formiate of ethyl was to compare its action with that of the acetate of methyl, with which it is isomeric. The action of the two is different; the acetate produces deep stupor without muscular excitement.

On the Neutralization of some Poisons by the Methyl and Ethyl Series.

The last line of research to which I shall refer in this Report relates to the employment of the members of the methyl and ethyl series for the purpose of neutralizing alkaloidal poisons. From the fact that iodide of potassium and iodide of methyl produce very definite curative effects in some forms of disease, it occurred to me that possibly they underwent change of constitution in the body, forming, with a foreign and injurious agent, a new compound.

This view was confirmed by an observation made some years ago while conducting experiments on the synthesis of cataract. I found then, and recorded the fact in Brown-Sequard's Journal in 1860, that while chloride of potassium and chloride of sodium would produce a synthesis of cataract, the corresponding iodide salts would not. Hence I concluded that the iodides, even in organisms so low as frogs, were decomposed. The question, therefore, came before me, whether the iodides would neutralize in the organism the action of some of the better known poisons of the alkaloidal type.

To test this the following research was made; it dated from the 24th of October last year, 1867.

Three solutions were prepared. *One* consisted of 2 minims of iodide of ethyl, mixed with 30 of water. *Two* consisted of 30 minims of water and alcohol, holding the $\frac{1}{30}$ of a grain of strychnia. *Three* consisted of $\frac{1}{30}$ of a grain of strychnia with 2 minims of iodide of ethyl and 30 of alcohol and water.

A frog was injected with the solution number 1. It became tetanic in one minute and a half. Another frog was injected with the solution number 3, *i. e.* the solution of strychnia and iodide of ethyl. This frog also became tetanic in one minute and a half.

The frog number 1 was now injected with a solution containing 5 minims of the iodide of ethyl; within ten minutes the spontaneous tetanus had ceased, and spasm produced under the influence of irritation was very much less. In twenty minutes there was entire relaxation, but with faint twitches when the skin was touched.

The frog number 2 was next injected with a solution containing 1 minim of iodide of ethyl. There was immediate relaxation of the tetanic spasm, and irritation brought on no spasm.

One hour after this the frog number 1 still twitched when touched, while

frog 2 remained relaxed and living, but paralyzed. Both frogs died on the following day, retaining their symptoms to the end.

It was clear in these two cases that the iodide of ethyl exerted an antidotal action to the poison, but as the animals died with different classes of symptoms, a further research was made.

A large frog was injected with 10 minims of the iodide simply. It seemed quite unaffected for some hours, but on the following day it died, presenting symptoms of general paralysis similar to the frog that had received the five-minim injection after the strychnia. Thus the question had to be solved whether any precise formula of neutralization could be arrived at. In one experiment I had not used enough iodide to overcome the spasm, in another I had thrown in so much of the iodide as to more than neutralize, and, in fact, to kill by the iodide itself. Can, then, any known quantities for exact neutralization be arrived at in a living body?

I believe they can, but up to this time I have failed, after the most careful study, to find the quantity. I can certainly prolong life twenty-four and even twenty-eight hours after a terribly intense dose of strychnia, but ultimately there is death.

Iodide of methyl acts in precisely a similar way as the iodide of ethyl, as do also the bromides of methyl and ethyl.

Another series of experiments were at the same time made with nicotin. On October the 26th, 1867, two minims of nicotin were injected subcutaneously into a large rabbit. The animal died in twenty-five seconds.

A second rabbit was injected with two minims of nicotin and two of iodide of ethyl. It died also in twenty-five seconds.

A third rabbit was injected with one minim of nicotin and ten of the iodide. It died in one minute and fifty-one seconds.

A guineapig and a rabbit were treated with ten minims of the iodide only. They remained well for several hours, but both died next day.

Again, varied experiments were carried out to get at the neutralizing proportions of these two agents, and guineapigs were made to replace the rabbits; but the point was never reached. The effect of a large dose of nicotin was modified, *i. e.* the convulsive action was prevented, but in the end there was death.

In my Report at the Meeting at Birmingham, I suggested that possibly it would be practicable to make new chemical compounds, substitution-compounds, in the living body. While I have been thinking and trying to work out this idea, Drs. Fraser and Crum Brown have been conducting the most singularly beautiful series of research bearing on the same question, but carried on differently. These experimentalists have shown conclusively that an intensely poisonous dose of strychnia can be rendered inert by first converting the alkaloid into a methyl-iodide.

This is a wonderful advance. But the question remains, can the same thing be done within the living body? Can a new chemical compound be produced there? When we consider the circumstances under which the substitution-compounds are made in the laboratory, I confess I am hardly prepared to see that they can be formed in the body. On the other hand, we have now evidence that to a certain extent iodide of methyl and ethyl are directly antidotal to strychnia or nicotin.

In the body, however, there are two distinct actions to be considered, the physiological action and the chemical. The antidotal effects of the methyl-iodide might, therefore, be due, not to chemical union or substitution, but to physiological neutralization.

To approach a conclusion on this particular point I moved from the iodides altogether, and from the monocarbon series altogether, and repeated some experiments, which I had commenced as early as 1864, with various nitrites of the bodies of which carbon is the base. I began with nitrite of amyl, passed to nitrite of ethyl, and next to the nitrite and nitrate of methyl. The results are rich in interest; for each one of these substances proves to be singularly antidotal to the acute action of strychnia. So remarkably is this true in respect to nitrite of amyl, that in a frog tetanized with strychnia I was able to hold back every convulsion for three days by the simple experiment of keeping the animal on a bed of moist moss, covering it with a bell-jar, and by introducing into the jar two minims of the nitrite every eight hours on a strip of paper.

But here came the singular fact, and in different degrees it was seen in all the other experiments; so soon as the bell-jar was removed, and the antidote was able to escape from the body of the animal, the strychnine tetanus returned. In one case, however, by great care in the experiment, a slightly tetanized frog was kept long enough under the nitrite to allow the effects of the tetanic poison to cease, and this animal recovered.

These truths are so convincing that I can have no hesitation in confirming another suggestion I made at the Birmingham Meeting, for the careful employment of the nitrite of amyl, by inhalation, in the treatment of tetanus in the human subject. The remedy can be inhaled from the alcoholic solution which I have already placed before the Section, and it may be applied, under cautious or, rather, careful administration, whenever there is spasmodic paroxysm.

But what is the action? I do not think there can be any doubt on the point in the case of the nitrites. It is clear that the action is purely physiological, because when the antidote is not renewed the action of the strychnine returns. I am bound at this moment to confine myself to the strict narration of this fact, without applying it by inference to the iodides, bromides, or other bodies of the organic series. Next year, after a new course of experimental research, I shall, I trust, be able to show the possession of some more definite knowledge on the subject.

I conclude. It is not a practice of mine to trespass beyond due bounds on the patience of an audience, and if on this occasion I may appear to have broken a wholesome rule, I really cannot apologize. The subject I have had to treat goes to the root of principle in the study of means for the cure—I am bold to say the cure, by true and certain scientific methods, of the diseases which most severely scourge the human family and many of the lower families in the scale of living organization.

Gradually, but surely as gradually, the curer of bodies will learn from the chemist and the practical physiologist that his remedies, rapid in action, easy in administration, positive in result, must all come from the organic compounds, which are of themselves a part of the organic nature.

Thus learned, the physician will exchange dogmatism for wisdom, faith for knowledge, and doubt for certainty. He will compete with his fellows by the pure struggle of intellect; he will be responsible for results without evasion, and his duties will be more solemnly his own; but he will stand, where he never stood before, a conscious master in his art; he will know in what he doth believe, and the world, assured by his exactitude, will soon learn to know none but him in his vocation.

Report of the Edinburgh Committee on the Action of Mercury on the Biliary Secretion. By J. Hughes Bennett, *M.D., F.R.S.E., Chairman and Reporter.*

At the Meeting of the Association in Dundee (1867), I read as a communication some of the results arrived at by a Committee which had been investigating the action of mercury as a cholagogue. The inquiry originated in a suggestion made by myself, in the annual address in medicine I delivered to the British Medical Association at Chester in 1866. The physiological department of Section D considered the results so interesting and important that a grant of money was voted in aid of the Committee's researches, with the understanding that a full report was to be made on the whole inquiry at the next Meeting of the Association to be held in Norwich. The Committee consisted of Dr. Hughes Bennett, Professor of the Institutes of Medicine and Physiology in the University of Edinburgh, the Chairman and Reporter, Dr. Christison, Professor of Materia Medica, Dr. Maclagan, Professor of Medical Jurisprudence, Dr. James Rogers, formerly of St. Petersburg, Dr. W. Rutherford, assistant to the Professor of Physiology, Dr. Gamgee, assistant to the Professor of Medical Jurisprudence, and Dr. Fraser, assistant to the Professor of Materia Medica, Edinburgh.

The first meeting of the Committee was held November 16th, 1866. On proceeding to consider by what method the action of mercury on the biliary secretion was to be accurately ascertained, the conclusion was arrived at that no kind of examination of the fæces could yield trustworthy results. Supposing that the chief and characteristic constituents of the bile found their way into the alvine evacuations unchanged, imperfection in the analytical methods at our disposal render their quantitative analysis impossible. The plan of ascertaining bile-acids indirectly by means of nitrogen and sulphur determinations of the alcoholic extract, while most unsatisfactory in the case of pure bile, is still more so when applied to the alcoholic extract of fæces. The method of Professor Hoppe-Seyler of Tübingen, who calculated the amount of bile-acids from the effect which their solutions exert upon the ray of polarized light, presents such complexity and difficulty as to render its systematic employment in any series of analyses altogether inapplicable. As to the colouring-matters of bile, there is no direct method known by which they can be estimated. But it was further argued that, did we even possess proper means of estimating the bile-products, it is only a small portion of such as are secreted by the liver which can be found in the alvine discharges. Bidder and Schmidt ascertained that the amount of unoxidized sulphur in them only represented one-eighth part of the total sulphur which the liver secretes, and that of the other constituents of the bile the larger proportion are absorbed. Indeed the utter impossibility of detecting the constituents of bile in the fæces is admitted by one of the most reliable physiological chemists of Europe, viz. Professor Hoppe-Seyler. That under the influence of purgatives unchanged bile is occasionally discharged from the bowel is true; but this furnishes no proof of any increase of that secretion; for under ordinary circumstances it is decomposed and absorbed in the alimentary canal, and any cause which increases the rapidity of its passage there, must render absorption and decomposition less complete.

As it was evident that no accurate information concerning the amount of bile secreted by the liver was to be obtained by an examination of the fæces, the Committee arrived at the conclusion that the formation of biliary fistulæ in living animals, and collecting the bile directly through such fistulæ from

the gall-bladder, was the only means open to them of determining how far mercury influenced that secretion.

History.

It next became necessary to ascertain what had been made out by previous observers as to the amount of bile secreted by the liver, under varied circumstances, through biliary fistulæ. For literary researches into this matter, the Committee are greatly indebted to Dr. Rogers. He informs the Committee, in his report on this branch of the inquiry, that efforts to establish biliary fistulæ and to collect the bile have been attended with extreme difficulty in the hands of all experimenters, and have led to a large mortality among the animals operated on. Of 18 dogs operated on for this purpose by Professor Schwann of Louvain, 10 died within a week after the operation, from its immediate effects; six in from eight to eighty days from inanition, although the appetite remained good. In 2, the choledic diet was reestablished. Some years afterwards he operated on 12 other dogs, so that the total number operated on amounted to 30; and Bidder and Schmidt inform us that of these one lived four months, and another a whole year, after the operation. The last-mentioned authors say*, "We shall not take into account the unsuccessful cases, of which the number at the commencement of our investigation of this subject was not very small." Again, they say, "After ten or twelve unsuccessful attempts to establish permanent biliary fistulæ in cats, we were obliged to have recourse to dogs." Dr. Flint, in his paper on a New Function of the Liver, does not mention the number of dogs on which he performed the operation; but it is evident that a great number perished. He says, "All the experiments made during the winter 1860–61 were unsuccessful, no animal surviving the operation more than three days." After a number of trials during the following winter, which were not more successful than the previous ones, he succeeded at last with one animal. There is every reason to believe that, had other experimenters informed us of their failures, the number of these would have been equally great. In the few cases which have succeeded, however, it is important to remember that a large amount of valuable information regarding the bile has been obtained that never would have been arrived at without them.

The operation performed by physiologists on animals in order to establish biliary fistulæ has, with a few modifications, been essentially the same, and will be subsequently described when detailing the experiments of the Committee.

The results arrived at may be divided into:—1, the amount of the biliary secretion in health, and the circumstances which influence it; 2, the special effect of mercury on the secretion of bile.

1. *Previous Researches to determine the amount of Bile Secreted in Dogs, and the Circumstances which influence it.*

Haller†.—In Haller's 'Physiology,' reference is given to several cases in which attempts had been made to ascertain the quantity of bile secreted in a given time by experiments on living dogs. The description of them, however, is so very vague and general that they possess little interest for the physiologists of the present day. Van Reverhord found the quantity of bile secreted by a dog in twenty-four hours to be 6 oz.; and Haller, estimating the secretion in the human subject at four times that in the dog, suggested 24 oz.

* Verdauungs-Säfte und der Stoffwechsel, 1852, page 125.

† Physiologia, tom. vi. page 605.

to be the quantity secreted daily in the healthy human adult. He likewise alludes to an interesting case of a man in whom a biliary fistula was formed in consequence of a wound of the gall-bladder. Tacconus, who saw the case, estimated the amount of bile discharged by the fistula at 4 oz.; but whether the expression "eodem tempore" refers to six or twenty-four hours, it is impossible to say—probably to the former.

Schwann *.—It was not till 1844 that any serious attempts were made to investigate this subject by Professor Schwann of Louvain. He made several interesting experiments, by means of biliary fistulæ, to ascertain the utility of bile in the animal economy. Unfortunately he does not appear to have carried out his intention of ascertaining accurately its amount.

Blondlot †.—In 1846 Blondlot succeeded in establishing a biliary fistula in a dog of middle size, in which he gives approximately 40 to 50 grammes as the amount of bile secreted in twenty-four hours. His estimate, however, was not made with great precision; for he only collected the fluid for short periods at a time, and could not therefore ascertain its exact amount in twenty-four hours.

H. Nasse ‡.—Heinrich Nasse of Marburg published in 1851 an interesting memoir giving an account of a series of experiments performed on one dog in which a biliary fistula had been established, and which lived afterwards five months and a half. His object was to ascertain the influence of the quantity and quality of the food on the biliary secretion. As we have not succeeded in obtaining the original work, the result of his researches will be subsequently tabulated as obtained from the abstract given of them in Canstatt §.

Bidder and Schmidt ||.—In 1852, Bidder and Schmidt, in their work on the Digestive Fluids, gave an account of the most elaborate experiments yet made to determine the amount of the biliary secretion. They succeeded in establishing biliary fistulæ in four dogs. In one dog the daily observations extended from Feb. 17th to April 15th, when he was killed. The bile was collected by holding a balloon-shaped glass over the fistulous opening for fifteen minutes at a time; and this was repeated daily from six to ten times successively. The varying amount of biliary secretion obtained at one period was corrected by the results obtained at other periods, and the average amount calculated from a large number of observations. This method, though excellent for determining the amount of the secretion at different periods of the digestive process, is, as regards the daily quantity, evidently unsatisfactory. Besides, as the dog did not consume the same amount of food under these varied circumstances, that might vitiate the result. To simplify the Tables, and render calculation easier, they estimated the amount of bile secreted at so much per kilogramme weight of dog. Thus, if a dog weighing 5 kilogrammes secreted 100 grammes of bile in twenty-four hours, it would be said that 20 grammes of bile were secreted for each kilogramme of dog in twenty-four hours. They estimate the average amount of bile per kilogramme in twenty-four hours at 19·999.

The following Table gives the average amount of biliary secretion in the four dogs, with the average amount of food per kilogramme taken hourly and daily. One kilogramme weight of dog gives 6 grammes.

* Müller's 'Archiv,' 1844, page 127.
† Essai sur les Functions du Foie, 1846.
‡ Commentatio de bilis quotidie a cane secretæ copia et indole. Marburg, 1851.
§ Canstatt's Jahresbericht, 1856, 1st Heft, p. 87.
|| Verdauungs-Säfte und der Stoffwechsel, 1852.

	1.	2.	3.	4.	5.	6.
In 1 *Hour.*						
Fresh bile	0·539	0·663	0·696	1·023	1·198	0·824
Dry residue	0·040	0·035	0·029	0·049	0·057	0·042
In 24 *Hours.*						
Fresh bile	12·936	15·912	16·704	24·550	28·750	19·99
Dry residue	0·960	0·840	0·696	1·176	1·268	0·988
Daily amount of food per kilogramme weight of dog.		32·49 flesh; 1·74 bacon and butter.	17·85 flesh; 7·87 milk.	79·51 flesh; 8·32 bread.	66·42 flesh; 8·59 bread (rye).	

The first column gives the quantity of bile obtained from recently formed biliary fistulæ, the four following ones the quantity obtained in cases of fistulæ of some standing, and the sixth gives the average amount of the different observations.

Bidder and Schmidt found that the amount of bile secreted in a given period varies much in different species of animals. Thus for every kilogramme of animal there is produced on an average—

Cat.	Dog.	Sheep.	Rabbit.	Goose.	Crow.
In 1 *Hour.*					
0·608	0·824	1·059	5·702	0·491	3·004 Fluid.
0·034	0·042	0·056	0·103	0·034	0·219 Solids.
In 24 *Hours.*					
14·50	19·990	25·416	136·84	11·784	Fluid.
0·816	0·988	1·344	2·47	0·816	5·256 Solids.

It appears remarkable that the rabbit should secrete five times as much bile as the other larger animals do, and that the crow should secrete so much more than the goose; but from the manner in which the bile-collections were made, little confidence can be placed in these results. They found that the amount of the biliary secretion was much influenced by the quantity and quality of the food and drink. Taking from six ounces to ten ounces of water produces a rapid increase of the secretion, attaining its greatest measure in from forty-five to sixty-one minutes after it had been taken, and diminishing as rapidly. They found that, when the food of cats consisted almost exclusively of fat, the secretion of bile was reduced to about the quantity furnished by fasting animals. Blondlot (p. 62) says that the use of fat increases the amount of bile; and Ritter and Nasse say that the addition of fat to the food increases the secretion—at least when the supply of flesh at the same time is not great. Bidder and Schmidt also ascertained that the quantity of the biliary secretion varies at different periods of the digestive process, and that it attained its maximum thirteen to fifteen hours after a meal. On this point it may be here observed that Arnold supposed it to reach its maximum two to four hours after solid food was taken, Kölliker and Müller generally from five to eight hours, and Dr. Flint from two to eight hours. Dr. Dalton, from observations made on a case of duodenal fistula, thinks biliary secretion is at its maximum an hour after feeding. Ritter and Nasse, like Arnold, remarked two maxima in the course of the day—the first occurring during the

first or second hour after feeding, the other so much the earlier the more scanty the supply of food.

In Bidder and Schmidt's tabulated observations on the first dog, it will be seen that the greatest amount of fresh bile was secreted between six and seven hours after a meal. It is true that the greater amount of dry biliary residue was found in one of the collections made from fourteen and a half to fifteen and a half hours after feeding; but in another quantity collected at the same period after feeding the amount both of fresh bile and dry residue was much less than that collected between six and seven hours after a meal. Again, of two quantities collected respectively on the 2nd and 6th of November, from fourteen to fifteen and a half hours after feeding, the amount of fresh bile in the first collection was only about the half of what was secreted from three to four hours after a meal; and in the second collection it was about half of that secreted from four and a half to five and a half hours after a meal. The tabulated observations on the third dog seem to give more support to Bidder and Schmidt's opinion; but quantities of biliary secretion given for different periods after feeding are too fluctuating to permit the amount of bile secreted at any given stage of digestion to be accurately estimated. The observations of Bidder and Schmidt themselves, therefore, do not support their own conclusion; and as this is opposed to those of other experimenters, it must be concluded that the amount of bile secreted varies considerably in the same animal, and at the same period of digestion, even independently of food and drink.

Arnold*.—In 1854 Dr. Arnold published a work on the 'Physiology of the Bile,' and afterwards made some additional experiments on the subject in 1857. The apparatus he employed consisted of a canula $4\frac{1}{2}$ centimetres long and 4 centimetres wide, attached by a screw to an elastic caoutchouc bag 10 centimetres long and 1 centimetre broad. Fifteen millimetres above this attachment, and at right angles with the canula, was a metallic plate, 12 millimetres in diameter. This plate was placed between the skin and the muscles; and the wound healed perfectly over it, preventing all escape of bile between the soft parts and the canula. The distal extremity of the bag had a cork stopper, by taking out which the bile collected in it could be removed. The operation was performed in the usual manner on a healthy dog of middle size, weighing 9·250 kilogrammes, on the 18th of June, 1853. The common duct was first tied close to the duodenum, and again half an inch from the gut. The portion between the two ligatures was then excised. Although after the operation the dog was exhausted, and vomited its food more than once, on the following day he appeared to be quite well. The bile flowed freely through the canula until July 1st, when it ceased. Another and wider canula, with a broader border, was then inserted. This also, subsequently, was so forced forwards by the contraction of the wound that no bile could flow, and the canula was withdrawn. The apparatus first inserted was then employed, and answered perfectly, as the canula was firmly fixed in its place by the wound healing over it; so that not a drop of bile escaped at its edges. From the 18th of June until the 6th of July, the dog was fed on bread, milk, flesh, and potatoes. It lost 375 grammes in weight during this period, without any perceptible derangement of digestion. The fæces were pultaceous, without any trace of bile-pigment, had a putrid odour, and contained a considerable quantity of fat, but no trace of muscular fibre. To prevent him from licking the bile he was muzzled. From July 6th to August 2nd he was fed entirely on flesh. From the 6th to the 9th

* Zur Physiologie der Galle, 4to, Mainz, 1854.

of July he ate daily 500 grammes of fat flesh. During this period the fæces were like clay, soft, and contained a quantity of fat. The weight of the body diminished rapidly, so that on the 8th it was 8·203 kilogrammes, and on the 9th 7·750 kilogrammes. He was then lean, but lively, and had 750 grammes of flesh, pretty free from fat, divided into three portions, which he ate morning, midday, and evening. During the period he lived on flesh his hair fell out largely, and could easily be pulled out in tufts without causing pain. There was also a large development of gas in the intestines, with borborygmi and liquid fæces. About the 20th of July they assumed their natural consistence, and were brown externally, though of an ash-colour internally. Each time the fistulous opening was interfered with or irritated, the fæces became softer and more liquid, and their odour more cadaverous; while, when consistent, it was less penetratingly putrid. From August 3rd to September 1st, the food consisted of old rye-bread, of which there was consumed, on an average, daily 470 grammes, and was commenced because the dog refused all animal food. During this period its weight increased to 8 kilogrammes, the emaciation disappeared, and the falling off of the hair diminished. Indeed the hair in a few months grew abundantly, so that it presented a black shining coat, as before the operation. The appetite returned, and he ate greedily. The digestion was good; the fæces of firm consistence, of a yellowish-grey colour, like that of the bread, and less offensive than when he was fed on flesh. Their quantity also was increased as three to two. Their average daily weight was 320 grammes; whereas, when fed on flesh, it was 210 grammes. He also drank more. When the diet was bread, he drank daily the average quantity of 450 cubic centimetres; when fed on flesh, only 340 cubic centimetres.

The quantity of bile secreted on the average, when fed upon 750 grammes of flesh and upon 470 grammes of rye-bread, is shown in the following Table:—

Daily food.	Weight of dog.	Bile secreted daily.	Bile solids daily.	Bile secreted daily per kilo.	Bile secreted hourly p. kil.
750 grms. flesh.	7·750 kilogs.	90·295 grms.	2·892 grms. to 3·056 grms.	11·65 grms.	0·486 grm.
470 grms. rye-bread.	7·812 kilogs.	63·024 grms.	1·662 grm. to 2·634 grms.	8·067 grms.	0·336 grm.

From hourly observations it appears that the largest quantities of bile were secreted during the first hours after getting food; drinking water also increased the secretion. The dog caught cold September 1st, and died September 3rd, from peritonitis. On September 4th the body of the animal weighed 7·512 kilogrammes. On dissection, it was found that where the ductus communis choledochus had been cut out, a new one three lines long was formed, having on one side of it a small collection of pus containing the ligatures. It was therefore believed that in a short time the common duct would have been reestablished. Round the plate of the canula a newly formed mucous membrane was discovered, continuous with the gall-bladder.

The following are the more important conclusions drawn by Arnold from the whole inquiry (p. 19):—1. Cutting off the bile from the intestines, if a sufficiently increased quantity of food can be digested, is not injurious to an animal. For two dogs of the same weight, one with and the other without fistula, the first will require five-eighths more flesh or three-fifths more bread than the second. 2. The quantity of bile secreted is influenced by the quantity and quality of the food. A dish of bread gives rise to a less secretion of bile than one of flesh. 3. From experiments on dogs with biliary

fistulæ, in consequence of the increased diet they require, no conclusion can be drawn as to the quantity of bile likely to be secreted in healthy dogs in proportion to the amount of food they take. 4. The quantity of bile secreted in proportion to the weight of the animal is estimated too highly by Bidder and Schmidt, and also by Nasse; because all animals with biliary fistulæ require much more than their ordinary food to keep up their usual weight, while the quantity of diet influences the amount of bile secreted. 5. Besides food, the drinking of water considerably increases the secretion of bile. 6. The nature of the food does not much influence the solid constituents of bile. Arnold admits, however, that in this respect Nasse's observations may be more accurate than his own. 7. The secretion of bile, apart from the influence that it exerts on the absorption of fat, plays an important part in the process of nutrition. 8. In Arnold's dog the biliary secretion was most copious during the first hours after taking food. After the fourth hour it began to diminish until the twenty-fourth hour, when it was least, but the diminution was not regular. His manner of collecting it, however, like that of Bidder and Schmidt, is objectionable, viz. at varying periods of fifteen minutes, half an hour, and an hour. Instead, therefore, of determining how much bile flowed in twenty-four hours, this was made to appear by multiplying so many times the half-hour or hour collections.

Kölliker and Müller* made some experiments on the bile during the years 1853 and 1854, of which they published an account in the Wurzburg Abhandlungen for 1855. They succeeded in establishing biliary fistulæ in three dogs. For one kilogramme of dog, they found in twenty-four hours—

Hours after food.	Fresh bile.	Dry residue.	No. of observations.
1 to 2	1·450	0·051	8
3 to 5	1·407	0·047	5
6 to 8	1·514	0·048	8
16 to 22	1·320	0·051	7

Another dog gave the largest quantity four to five hours after feeding, and least after nineteen to twenty-one hours. A third dog gave the maximum five to six hours after a meal, and not much less after sixteen or seventeen hours. They found, as other observers had done, that the quantity of food consumed has a decided influence on the quantity of the biliary secretion. When, for example, a dog ate 18½ ounces of flesh in twenty-four hours, the bile collected amounted from 5·3 to 6·6 grammes in an hour, but when it ate 33½ ounces of flesh, it was increased from 7·5 to 7·8 grammes. It is important to observe that the calculations of Kölliker and Müller, like those of Bidder and Schmidt, were derived from collections of bile made during a quarter of an hour, half an hour, and occasionally one hour, and the amount per day was estimated from the averages of these. In no case was it collected continuously for twenty-four hours.

Scott †.—Dr. Scott appears to have been the first who collected all the bile secreted by a dog during twenty-four consecutive hours. We must refer to his paper for a description of the method he adopted for collecting it, and for the account he gives of his interesting and carefully conducted experiments and analyses. He avoided the error liable to occur in calculating the amount of bile secreted in twenty-four hours from quantities obtained during a part only of that period. He estimated the amount of fresh bile given off in twenty-four hours at about 23·15 grammes; of dried residue at 1·13 per kilogramme.

* Würzburg Abhandlungen für 1855, Band V. † Beale's 'Archives,' vol. i.

Dalton*.—Dr. Dalton of New York attempted to ascertain the amount of bile which passed into the duodenum from the choledic duct by means of a duodenal fistula. But as in this manner it is obviously impossible to determine the amount of the entire quantity given off by the liver, no account of his researches need be given.

Flint†.—The last experimenter we need cite is Dr. Flint of New York. As his object, however, was rather to ascertain the amount of cholesterine secreted by the liver, than to determine the quantity of biliary secretion, he does not give us much information on this point. In one dog the bile was collected for thirty minutes at a time during various periods of the day, and was found to be secreted at its maximum four hours, and at its minimum twenty hours, after feeding. The dog weighed 10 pounds; and there were collected, in the twenty-four hours, 243·233 grains—an amount which gives an index of the quantity secreted during that period. He further says that, disregarding slight variations, which might be accidental, it may be stated in general terms that the maximum flow of bile from the liver is from the second to the eighth hour after feeding, during which period of time it is about stationary.

We here subjoin a Table containing the results of the experiments of different physiologists who have investigated the subject of the biliary secretion. With the exception of the results of those of Dr. Flint and Dr. Scott, the Table, of which the arrangement is slightly changed, is taken from Canstatt's Jahresbericht for the year 1863, No. 1. p. 141. The weight is given in grammes.

Names of observers.	Amount of bile secreted in 24 hours per kilogramme weight of dog.		Food taken in 24 hours per kilogramme weight of dog.	Quantity of bile secreted in 24 hours for 100 grammes of food.	
	Fresh bile.	Dry residue.		Fresh bile.	Dry residue.
Nasse, 1851	19·2	0·685	155 flesh	12·3	0·440
	22·8	0·700	208 ,,	11·1	0·337
	23·1	0·784	260 ,,	8·9	0·300
	24·0	0·765	At will	...	...
	28·4	0·760	,,	...	...
	17·7	0·446	100 flesh and 100 br.	...	...
	17·9	0·400	130 ,, 100 ,,	...	...
	12·2	0·500	87 bread	13·9	0·575
Bidder and Schmidt, 1852.	15·9	0·840	32·4 flesh, 1·7 fat	49·3	2·608
	16·7	0·696	17·8 ,, 7·8 milk	83·5	3·48
	24·5	1·176	79·5 ,, 8·3 bread	25·7	1·23
	28·7	1·268	66·4 ,, 8·5 ,,	35·1	1·54
Arnold, 1854–57 ...	11·6	0·373	96 flesh	12·0	0·385
	8·1	0·215	60 bread	13·4	0·357
Kölliker and Müller, 1853.	32·7	1·034	...	...	...
	32·6	1·290	98 flesh	...	...
	26·1	1·013	92 ,,	28·56	1·694
	21·5	0·748	94 ,,	22·85	0·792
	36·1	1·162	64 ,,	56·50	1·816
	53·6	1·683	94 ,,	56·7	1·79
	32·1	...	37·9 bread, 90 cubic centimetres of milk	...	...
Scott, 1858	23·11	1·128	58·7 flesh, 10·3 milk	35·0	1·6
Flint, 1862	11·98	0·440	...	...	...

* Physiology, p. 190, 3rd edit.

† American Journal of Medical Sciences, vol. xliv. p. 366.

2. *Previous Researches to determine the Influence exercised by Mercury on the Biliary Secretion.*

Nasse*.—Professor H. Nasse was the first who attempted to ascertain, by experiment on the dog with biliary fistula, the influence of mercury on the secretion of bile. It is stated in Canstatt that the result of his experiments was that calomel increased the absolute quantity of the bile, but diminished its solid constituents.

Kölliker and Müller administered to one of their dogs, which had biliary fistula, 4 grains of calomel at ten o'clock on the morning of the 28th. Five half-hour observations made after midday gave an average of 3·823 grammes of bile excreted, an amount a little above that of previous averages. On the following day, however, four half-hour observations gave on an average 3·267 grammes,—that is, rather less than the usual average.

On the 21st and 29th days the dog took again 4 grains of calomel, but the biliary secretion, instead of increasing, diminished. Seven observations of half an hour each, from the 28th to the 31st day, gave an average of only 2·183 grammes, and the bile at the same time was of a brownish colour, and so thick that at last it scarcely dropped from the canula. This circumstance was undoubtedly owing to the dog's health, which was bad. It had lost weight, had diarrhœa, greyish-coloured and even later bloody stools. For several days at this period the animal took only a little bread and milk.

Dr. Mosler†, in his investigations, proposed to himself the question, "What substances introduced into the blood appear in the bile?" In some of the experiments a solution of the substance to be tried was injected into the blood, in others the medicine was given by the mouth, and the bile afterwards tested, to ascertain if it contained any trace of the substance administered. With regard to mercury, he tells us that on the 23rd of May, at seven o'clock A.M., 5 grains of calomel in a little bread and milk were given to a dog, who had a completely healed biliary fistula. All the bile secreted till three o'clock P.M. was collected by means of a sponge and tested for mercury, but not the slightest trace of it could be discovered. At four o'clock P.M. 10 grains of calomel were administered to the same animal, and for greater accuracy a small tube with a caoutchouc bag attached was introduced into the fistula, and kept there till next morning. No trace of mercury was found in the collected bile, and no striking increase of the biliary secretion was remarked. After this experiment the animal was dull, ate less than usual, and had thin very offensive stools. To make a trial of the drug in smaller doses, Dr. Mosler gave the same animal one grain of calomel every hour from the 25th to the 26th of May, so that altogether 25 grains of calomel were given; no trace of mercury could be found in the collected bile. To another powerful dog with biliary fistula he gave, on the 19th of August, at nine o'clock, three pills, each containing 3 grains of calomel. Next morning at six o'clock A.M., three similar pills were given, and at nine o'clock two more—so that the dog had 30 grains of calomel in eighteen hours. The bile discharged from the fistula was carefully collected by a sponge, from three o'clock on August 11th till the same hour on August 12th. Compared with the quantity collected during twenty-four hours on the day previous to that of the experiment, there was no striking increase of bile, nor did it contain any trace of mercury. He repeated this experiment with 24 grains of calomel with the same negative result. Dr. Mosler concludes

* Cantsatt's Jahresbericht, 1852, Heft. i. p. 156.
† Virchow's 'Archiv,' Band xiii. S. 29 (1858).

from these experiments that, when mercury is administered in the form of calomel, either in small or large doses, it does not pass so rapidly into the bile, nor produce the marked increase of the biliary secretion that medical men imagine. It is much to be regretted that Dr. Mosler did not measure the bile passed during these experiments, which would have given far more value and precision to his observations.

Scott.—The only other experiments made to determine the influence of mercurial preparations or, rather, of calomel on the biliary secretion with which we are acquainted are those of Dr. Scott, who deserves great credit for the careful and scientific manner in which he has carried them out. We shall have occasion, however, to indicate some circumstances which seem clearly to show that they must be regarded rather as valuable contributions to aid us in determining the influence of calomel on the biliary secretion than as data which, of themselves, warrant any definite conclusion; indeed Dr. Scott himself has fully admitted the truth of this remark. Dr. Scott made four trials with calomel, in which he estimated the amount of increase of the biliary secretion by taking the average of two days previous and of two days subsequent to its administration.

In the first trial 3 grains of calomel were given to the dog at three o'clock P.M. on the 13th of June*. The daily average amount of bile secreted on the 11th and 13th of June was 1960 grains, and that of bile secreted on the 14th and 15th, 1358 grains, showing an average diminution of 602 grains for each of the two days subsequent to the administration of the calomel.

In the second trial 6 grains of calomel were administered at eleven o'clock A.M. on the 16th of June†. The amount of bile secreted during twenty-four hours, and collected on the morning of the 16th, was 1639 grains, and of that secreted during the subsequent twenty-four hours, and collected on the 17th of June, was 518 grains, indicating a diminution of 1121 grains in the biliary secretion during twenty-four hours after the administration of the calomel.

In the third trial 12 grains of calomel were given at 4.30 P.M. on the 3rd of July, the average daily secretion of bile for two previous days (2nd and 3rd of July) amounting to 3044 grains, and that for the two subsequent days (4th and 5th of July) to 2720 grains, showing a diminution of 324 grains on the average daily quantity of bile secreted after the administration of the calomel.

In the last trial 12 grains of calomel were given at 5.45 P.M. on July 7th; the daily average amount of biliary secretion on the two preceding days (the 6th and 7th) being 2658 grains, and on the 8th and 9th July being 1724 grains, showing a diminution of 934 grains in the daily average quantity of bile secreted after the administration of the calomel.

We subjoin a Table of the daily amount of fresh bile collected for several days, in order that our subsequent remarks may be intelligible to the reader. The "†" before the dates indicates the days on which calomel was administered.

* The bile secreted during twenty-four hours was always collected on the morning of the day indicated. The amount obtained on June 12th was not used in calculating an average, as a considerable quantity was lost in collecting it.

† The amount of bile collected on the 15th was not used in making an average, probably because Dr. Scott supposed the secretion of the previous twenty-four hours was still under the influence of the calomel.

Amount of Bile secreted in Twenty-four Hours, in Grains.

June 11	1628·00	July 1	2168·051
„ 12	1767·700	„ 2	2941·239
†„ 13	2293·527	†„ 3	3148·400
„ 14	1819·636	„ 4	2560·300
„ 15	896·680	„ 5	2881·500
†„ 16	1639·968	„ 6	2644·300
„ 17	518·701	†„ 7	2673·900
„ 18	1810·450	„ 8	1963·500
„ 19	817·717		

Dr. Scott concluded that all the trials gave but one result, viz. "a diminution in the amount of bile and bile solids secreted after the administration of large doses of calomel." We are of opinion, however, that the diminution is not nearly so great as he has made it appear; thus, for example, if in the first trial we set aside the results of June 12th (as Dr. Scott has done), and only take the amount of bile secreted during the twenty-four hours previous and subsequent to the administration of calomel (as Dr. Scott has done in the second trial), the amount of decrease will be considerably less than he has calculated it to be.

Again, if we take the average amount of bile collected during two days previous and two days subsequent to the administration of the second dose of calomel, the result will be very different from what Dr. Scott's calculations make it. Instead of a diminution of 1121 grains, it will amount only to 104 grains; and we must not overlook the fact that on the day when the calomel was administered the dog did not get any food.

Dr. Scott does not mention at what hour of the morning the bile was collected. If we suppose it was collected at 10 o'clock A.M., twenty-three hours would thus be left for the action of the calomel, which was administered at 11 o'clock A.M. on the preceding day. It might be said that the action of the calomel would not be exhausted in that time, and that we ought not, therefore, to admit the collection of bile of the 15th into the calculation for obtaining a daily average amount on the two days previous to the administration of the calomel. On June 18th, however, the second day after the second administration of calomel, the amount of biliary secretion increased from 518 grains on the 17th to 1810 grains on the 18th, 171 grains more than the quantity secreted on the 16th, a day on which calomel could not have had any influence on the amount. Consequently we must conclude that the influence of the calomel did not extend, in this case, to the second day after its administration; or, if it did, it was not to diminish, but to increase very largely the secretion. Up to the present time we know little or nothing of the duration of the action of a dose of calomel on the biliary secretion; so that we have no reason to assign a period of two days, rather than of one or of three, as the duration of its action. It would be to ascribe in the one case an increase and in the other a diminution to the same cause; that is, the action of the mercury on the second day after its administration. In short, the number of Dr. Scott's observations are far too few, and not sufficiently long continued, to allow us to draw any definite conclusions from them.

It must, I think, be evident, from this notice of all that has been previously accomplished, that no exact information has yet been obtained as to the influence of mercury on the secretion of bile, or as to any other action it may exercise on the liver.

Description of the Mode of operating for Biliary Fistulæ and of collecting the Bile practised by the Committee.

All the operations were performed by Dr. W. Rutherford, who ultimately succeeded in overcoming the great difficulties which presented themselves. The propriety of collecting the bile for a period of at least twenty-four hours at a time was considered incumbent to avoid error, a proceeding which caused great trouble and constant failures; it was considered necessary, however, in order to avoid the obvious fallacies into which all previous experimenters, with the exception of Dr. Scott, had fallen. In now giving a detailed description of the method followed, the Committee are of opinion that they will save future experimenters much of that trouble and mortification which, from want of experience, they themselves encountered. It will be regarded as more valuable in consequence of the modifications which have been introduced having led to a far greater amount of success than has attended the efforts of other physiologists.

1. *Operation for establishing Biliary Fistulæ.*

1. Place the animal under the influence of chloroform, taking care to administer it slowly with an abundant admixture of air.

2. Open the peritoneal cavity by an incision extending from the xiphoid cartilage to the umbilicus. Before opening the peritoneum, all bleeding should be stopped.

3. Make an incision through a non-vascular part of the omentum, to the same extent as the external wound.

4. Find the gall-bladder and seize the most prominent part of its fundus with artery forceps. See if the fundus can be brought to the linea alba without subjecting it to any tension. If it can, proceed with the operation. If it cannot, judging from the experience of the Committee, it is better to abandon the operation altogether, as the dragging of the gall-bladder will almost certainly give rise to peritonitis, or such irritation as will prevent adhesion of the fundus to the cut edges of the linea alba.

5. Find the common bile-duct; draw the duodenum gently downwards and towards the left side of the animal, and the liver upwards and to the right, so as to stretch the duct.

6. With a blunt-pointed bistoury make an incision about one-eighth of an inch in length along the duct about its middle; gently isolate it with the point of an aneurism needle, pass the aneurism needle with a double strong silk ligature round the duct, and tie it in two places, at a sufficient distance from each other to allow of the duct being *simply divided* between them. After division of the duct cut the ligatures close.

7. Observe at what part of the linea alba the fundus can be most easily retained. Pass a curved needle with a silk ligature through the skin, linea alba, and gall-bladder on either side of the fundus, so as to stitch the gall-bladder to the linea alba, and retain it there.

8. Make a slit by means of a sharp-pointed bistoury in the most prominent part of the fundus, and allow the bile to flow out, taking care to hold a sponge at the side of the opening to prevent, as much as possible, the entrance of bile into the peritoneal cavity. With the same view, the animal should be turned on its side before the opening is made in the gall-bladder. This opening should be just large enough to admit easily a piece of india-rubber tubing about two lines in diameter.

9. Introduce a portion of india-rubber tubing of the above calibre into the aperture in the gall-bladder, put a silk suture through it, and fasten it to the ligatures holding the fundus to the linea alba, in order that the tube may be kept from coming out.

10. Close the wound in the abdomen by interrupted sutures, placed deeply in the linea alba, and then connect the edges of the skin in the same way. The skin should not be closed completely around the tube, but should be left open for an inch or so, in order that blood may be prevented from accumulating.

11. The projecting extremity of the tube should be cut within a quarter of an inch from the abdominal wall, in order that when the dog lies on its face there may be less danger of closing the tube by its being bent upon itself.

12. The tube should be removed at the end of forty-eight hours or so, for then adhesions will in most cases have taken place between the gall-bladder and linea alba, which the continued pressure of the tube would only tend to break up. The dogs operated upon by the Committee were never kept muzzled after the operation, and no dog ever interfered with the elastic tube.

13. The operation should always be performed when the stomach is empty, for if distended it is a most serious impediment to the operator. Very soft sponges, perfectly freed from all sandy particles, should be used, and the greatest care should be taken to prevent hairs from getting inside the peritoneum.

14. In male dogs the urine is apt to be discharged into the wound during the operation, and against this the operator must carefully be on his guard.

15. Great care should be taken to prevent bleeding into the peritoneal cavity. Any accumulation of blood inside the abdomen gives rise almost certainly to peritonitis. In all cases a little bile escaped into the peritoneum, but it seemed to produce no injurious effect.

16. The ligatures around the common bile-duct usually become encysted. The wound almost always heals by first intention; this union is very rarely permanent in the cutaneous wound, however; commonly pus is formed between the skin and the wound in the linea alba. When such is the case, sutures must be removed from the cutaneous wound to give free exit to the purulent matter. No lotions or other dressings are necessary for the wound. The bile as it flows over it forms an excellent dressing, under which healthy granulation proceeds, in most cases with rapidity.

17. For two days after the operation the animal should be fed on milk, given in small quantities at a time, so that the abdomen may not be distended.

The above mode of performing the operation differs from those described by other operators in two particulars:—1. The mode of fixing the fundus of the gall-bladder to the abdominal wall. Bernard recommends a clamp to fix the fundus to the edges of the wound, and act as a canula also. 2. In the non-removal of any portion of the common bile-duct. Other operators recommend that two ligatures be applied to the common duct, one close to the duodenum, the other close to the junction of the cystic with the hepatic duct, and that the intervening portion should be excised. The object is to prevent as much as possible the reestablishment of the duct, a contingency which appears to have been very liable to occur in the experience of other observers. The shock produced by cleaning and removing the whole duct is very great, owing to the extensive injury of the sympathetic nerves; and the danger from hæmorrhage is most serious.

Since the removal of any portion of the common bile-duct has been abandoned, the success attending the operations of the Committee has been unprecedented. In only two out of the thirty-three dogs operated on has the

common bile-duct become reestablished; in one of these nearly the whole duct had been excised, in the other the duct had simply been divided between the two ligatures.

The experience of the Committee has shown that young dogs are not suitable for the operation, only *full-grown strong* good-tempered dogs of any breed should be selected. Had the Committee been aware of this precaution, their success as regards the number of useful fistulæ might have been greater even than it has been.

2. *Method of collecting the Bile.*

The collection of the bile may be begun usually within a fortnight after the operation, as soon indeed as the fistula can bear the daily pressure of a silver canula. Before its insertion into the fistula, it is well to wait until the whole of the wound except the fistulous opening is completely healed. During the healing process, the fistula must be kept patent by the daily passage of a glass rod, which serves admirably the purpose of a bougie; for notwithstanding the flow of the bile, the canal has a great tendency to close.

The great difficulty which the Committee have had to overcome, has been the daily collection of bile for a period of twenty-four hours. The following apparatus, devised by Drs. Rutherford and Gamgee, has been found to accomplish the end perfectly.

The canula used was that of Scott (Beale's Archives, vol. i. p. 210), with the cup removed, and the holes in the tube filled up. The Committee found that in the very first case in which they used Scott's canula, the cup failed to fit the skin accurately, and soon produced ulceration by its pressure. They have found that there is no need for providing for an escape of bile along the side of the canula, provided a *perfectly free* exit be allowed *through* it. The canula was retained in the fistula by elastic bands attached to it, and passed round the body of the dog. These bands were fastened to each other by hooks and eyes, which permit of their easy removal and adjustment. Scott collected the bile in a bottle. It appeared to the Committee that an elastic bag tied on the free end of the canula would be less apt to be damaged by the movements of the animal. They found, however, that a much more satisfactory method is to collect the bile flowing from the canula by means of a large sponge. In this way *no resistance* is offered to the flow of bile through the canula—such as is apt to occur when the bag is used, by its folding over the free end of the tube. This acted as a valve, which resisted the feeble pressure with which the bile flowed through the fistula.

The sponge was placed in a tin box, fixed round an oval opening on the abdominal aspect of a thick gutta-percha shield, which extended from the fore legs to a little behind the umbilicus. The shield was made to fit accurately the body, so that it might have no tendency to turn round when the animal lay down. It embraced three-fourths of the circumference of the body, and the one side of it was connected with the other over the animal's back by means of leather straps with buckles. Between the back and these, a soft leather saddle was placed to prevent ulceration by their pressure. With the same view a flat bag filled with air was placed between the shield and the sternum, and a piece of thick-walled india-rubber tubing an inch or so in diameter, was placed between the skin and the posterior part of the shield. To this the bag and tube were both immoveably fixed.

The shield tends to slip backwards, owing to the pyramidal shape of the body of the animal. To prevent this, a leather collar must be placed loosely round the neck, and the anterior edge of the shield fixed to it by thick twine

Mercur und Syphilis (Berlin, 1861), pp. 110–114.

† Transactions of Med. and Phys. Society, Bombay, 1841, p. 11.

TABLE I.—SHOWING THE CONSTITUTIONAL EFFECTS OF MERCURY ON SIX DOGS

Dogs without Biliary Fistulæ

Dog A—[illegible] weight 30½ lbs.

Days.	Amount of corrosive sublimate given.	Effects.
[illegible]	[illegible]	[illegible]

Dog B—Collie, 5 months old, weight 18¾ lbs.

Days.	Amount of corrosive sublimate given.	Effects.
		[illegible]
1st day	·10 grain.	No change.
2d "	·40 "	" "
3d "	·40 "	" "
[illegible]	[illegible] "	" "
[illegible] "	·55 "	" "
6th "	·70 "	" "
7th "	·80 "	" "
[illegible] "	·80 "	Colour of fæces changed from brown to greenish brown, appetite impaired.
9th "	No mercury. ⅛th grain [illegible]	Diarrhœa, fæces greenish yellow.
[illegible]	No mercury [illegible]	Diarrhœa profuse; fæces [illegible] Slight [illegible]
[illegible]	No mercury [illegible] given.	Diarrhœa profuse; fæces of [illegible] abundant. Decided salivation. Gums [illegible]
12th "	No medicine given.	Nasal discharge; muco-purulent, very profuse. Salivation less marked than on previous day. [illegible]
13th "		Found dead. [illegible]

Dog C—Skye Terrier, 15 months old, weight 24½ lbs.

Days.	Amount of corrosive sublimate given.	Effects.
		Animal in excellent health [illegible] light brown.
1st day	·30 grain.	No change.
2d "	·70 "	" "
3d "	·80 "	" "
[illegible] "	[illegible] "	" "
5th "	·80 "	Appetite impaired.
6th "	1·60 "	No change.
7th "	1·60 ". 30 mins. tinct. opii given.	Slight diarrhœa, fæces brown.
8th "	No medicine given.	Profuse salivation. Breath very fœtid. Slight nasal discharge. Slight diarrhœa, [illegible]
9th "	·80 grain	No change.
10th "	..	Dog found lying in the [illegible] with a stream of [illegible] mouth. Breath very fœtid. Ulcers on the gums, on [illegible], and on the inside of the lips. The ulcers have a dark-grey surface. Slight diarrhœa; fæces contain blood. Dog died in the afternoon with [illegible] [illegible]. Weight 21¼ [illegible]

Dogs with Biliary Fistulæ

Dog D—Young Retriever, 6 months old, weight 11½ lbs.

Days.	Amount of corrosive sublimate given.	Effects.
		Animal is rather weak; fæces clay-coloured.
1st day.	1·6 grain given in two doses, with [illegible] interval between them.	Twenty hours after the first dose of ·8 of a grain were given, a nasal discharge [illegible]. Two hours after the second dose it was observed to be exceedingly weak; it was in a state of constant tremor, and staggered in attempting to walk. Liquid fæces of a clay-colour mixed with blood were passed. Nasal discharge [illegible]. No apparent salivation. No fœtor of breath.
2d "	..	Dog found dead thirty-six [illegible] was given. Weight 11 lbs. (See Dog 5, Table IX.)

Dog E—Bull-dog 2 years old, weight 38½ lbs.

Days.	Amount of corrosive sublimate given.	Effects.
		Animal is in excellent health; fæces clay-coloured.
1st day.	·4 grain.	No change.
2d "	·8 "	" "
3d "	·8 "	" "
[illegible] "	·8 "	" "
5th "	·8 "	" "
6th "	·8 "	" "
7th "	·8 "	" "
8th "	1·2 "	" "
9th "	1·6 "	" "
10th "	2 grains.	" "
11th "	3 "	" "
12th "	2 "	" "
13th "	4·5 "	Appetite impaired. Breath [illegible]
14th "	No mercury given.	Slight nasal discharge. Profuse salivation. Stream of saliva flowing from the [illegible] blood in fæces, which are of a clay-colour.
[illegible] "	.	Died during the night. Weight 31½ lbs.

Dog F—Collie, 18 months old, weight 37 lbs.

Days.	Amount of corrosive sublimate given.	Effects.
		Animal is in excellent health, [illegible], clay coloured.
1st day.	·4 grain.	No change.
2d "	1·6 "	" "
3d "	1·6 "	" "
[illegible]	3 grains.	" "
5th "	2 "	" "
6th "	4·5 "	Appetite much impaired.
7th "	6 "	Fæces slate-coloured, semi-solid.
8th "	No mercury given.	Slight nasal discharge. Fœtid breath. Salivation. Saliva dropping from mouth. Ulcers have formed in the skin [illegible] the ulcers are circular, and about the size of half-a-crown. Fæces slate-coloured.
9th "	.	Nasal discharge and salivation [illegible]. Dog vomits [illegible]. Blood in fæces [illegible] semi-solid and of a slate-colour.
11th "	.	Died during the night. Weight 30 lbs.

Totals:

Dog A	Dog B	Dog C	Dog D	Dog E	Dog F
[illegible] during a period of [illegible] days.	[illegible] grains given during a period of [illegible] days.	7¼ grains, given during a period of 9 days.	1⅗ grain, given during 1 day.	19½ grains, given during a period of 13 days.	$19\frac{1}{10}$ grains, given during a period of 7 days.

APPEARANCES FOUND ON DISSECTION

	Dog A	Dog B	Dog C	Dog D	Dog E	Dog F
Mouth and Salivary Glands.	[illegible] slight ulceration under [illegible]. Vascularity of [illegible]	Tongue pale, œdematous. No ulceration. Vascularity of salivary glands not increased.	Tongue covered with a white fur. Ulcers inside lips on gums and below margin of tongue. Vascularity of salivary glands not increased.	Nothing abnormal in the appearance of the mouth or salivary glands.	Tongue pale. Gums ulcerated.	Tongue pale and œdematous. No ulceration.
Stomach.	[illegible] with mucus. [illegible]	Contained a quantity of partially digested food. Mucous membrane healthy.	Empty. Mucous membrane healthy.	Contained partially digested food. Mucous membrane healthy.	Contained a large quantity of colourless watery fluid. Mucous membrane healthy.	Contained a large quantity of colourless watery fluid. Mucous membrane healthy.
Intestine.	[illegible]	The mucous membrane of the small intestine was marked with bright red lines and patches from the [illegible] the mucous membrane [illegible] is quite pallid. Duodenum [illegible] of an orange-yellow colour.	Marked redness of mucous membrane of duodenum. Slight redness of jejunum and ileum. Mucous membrane [illegible] marked with bright red striæ running longitudinally. Duodenum contained a little bile; the large intestine contained some bloody fæcal matter.	Marked redness of mucous membrane in the jejunum. [illegible] matter contained fæces mixed with blood.	Bright red [illegible] membrane. Most marked in the former. Mucous membrane of large intestine marked with bright red striæ.	Mucous membrane of small intestine covered with bright red patches from the pyloric orifice of the stomach to the ileo-colic valve; they were most marked in the jejunum. Large intestine marked with longitudinal bright red striæ.
Liver and Gall-Bladder.	[illegible] with greenish-yellow [illegible]	[illegible] orange-yellow bile. Hepatic cells apparently normal.	Same as the preceding.	Engorgement of hepatic venous system. Hepatic cells apparently normal.	Same as the preceding.	Same as the preceding.
Other Organs.	[illegible] Hypodermic [illegible] where the injections [illegible]. Other organs [illegible]	Pancreas very vascular. Congestion of lower lobe of right lung. A layer of lymph on the visceral pleura of this lobe. Other organs normal.	Pancreas very vascular. Hypodermic tissue œdematous where the injections had been made. Other organs normal.	Other organs normal.	Pancreas very vascular. Small abscesses under the skin in some of the sites of injection. Other organs normal.	Pancreas very vascular. Suppuration under the skin of the whole back and sides where the injections had been made. Ulcers in the skin. Other organs normal.

or leather straps with buckles. If the dog be a male, means must be taken to prevent the urine from reaching the sponge. This is effectually done by a sheet of thin india-rubber, laced round the posterior part of the shield and body in front of the penis, so as fairly to prevent the access of a single drop of urine. The whole apparatus was removed, washed and reapplied once in the twenty-four hours. The sponge was then weighed and placed in the shield dry. At the end of the period it was removed and weighed again, to ascertain the amount of bile. Two sponges are necessary for observations on a single dog, each sponge used on alternate days. They must be cleaned, after the collection of bile, with great care. It was found best to wash them in dilute hydrochloric acid, in order that they might be thoroughlydisinfected, for putrid matter soon produces decomposition of the bile.

The shield should be firmly secured on the animal to prevent its being moved. The Committee have in only one instance found it necessary to muzzle a dog while it wore the apparatus.

The dogs were kept in large cages, the lower half of the sides and entire floor of which consisted of sheet zinc. The floor sloped to a central hole, through which the urine was collected. The dogs were mostly taken out to the open air for a few hours daily.

Observations to determine how far Dogs are subject to the action of Mercury.

The Committee had not proceeded far with their experiments, before it became evident that a preliminary investigation was necessary, in order to determine how far dogs are capable of being influenced by mercurials. Although in veterinary and other works it is admitted that this animal may be salivated, although Overbeck states that by means of frictions with mercurial ointment he succeeded in producing marked salivation with spongy gums in three dogs out of five *, and Murray in his experiments with large doses of calomel also produced salivation in one dog †, the Committee were of opinion that further careful observations should be made on this point.

Accordingly great pains were taken by Dr. Gamgee to produce salivation in two dogs, by means of inunction of mercurial ointment, during the winter and spring of 1867. The hair of the animal was shaved from the back, and daily frictions made with the hand on the naked skin with strong mercurial ointment. In one dog a drachm of the ointment was rubbed in daily for twenty-eight days, and in another for eight days. No marked symptoms were produced, nor was their health impaired. In the first of these dogs a most elaborate series of observations on the urine was made to determine whether that secretion was in any way influenced. These consisted of careful analyses before and after the inunction, but with a negative result.

The frictions occasioned so much trouble and loss of time, and appeared to be attended with such little result, that it was resolved to adopt the more commodious method of subcutaneous injection of a solution of corrosive sublimate. This investigation was undertaken by Dr. W. Rutherford, who carried it to a successful termination, as seen in Table I.

It will be seen from Table I. that of the six dogs experimented on, three had, and three had not biliary fistulæ established. This selection was made with a view to ascertain whether or not the existence of a biliary fistula affected the action of the mercurial. Of the six dogs, five were salivated by

* Mercur und Syphilis (Berlin, 1861), pp. 110–114.

† Transactions of Med. and Phys. Society, Bombay, 1841, p. 11.

the drug; of these, three (Dogs A, B, and C) were small dogs without fistulæ, while two (Dogs E and F) were large strong dogs with fistulæ.

In dogs A and B the action of the drug upon the salivary glands was inferred from the occurrence of unusual wetness of the mouth merely; while in dogs C, E, and F a stream of saliva was observed flowing from the mouth.

In the three dogs without fistulæ—aged 5 (Dog B), 12 (Dog A), and 15 (Dog C) months respectively,—all of them small animals, decided salivation followed the administration of $4\frac{1}{4}$ grains of corrosive sublimate, extending over a period of eight days, to the dog aged 5 months; of $12\frac{1}{5}$ grains, extending over a period of eighteen days, to the dog 12 months old; and of $7\frac{1}{5}$ grains, extending over a period of nine days, to the dog 15 months old.

In the two large strong dogs (Dogs E and F) with biliary fistulæ, much larger quantities of the drug were required to produce well-marked salivation. $19\frac{1}{10}$ grains, extending over a period of seven days, to dog F, aged 18 months, and $19\frac{1}{2}$ grains, extending over a period of thirteen days, to dog E, aged 24 months. The dog which was not salivated (Dog D) was a retriever 6 months old, which was poisoned by $1\frac{3}{5}$ grain of corrosive sublimate, given in two doses during twenty hours.

In all the six dogs a discharge of mucus from the nostrils was observed during the administration of the drug; in some cases it preceded, in others it was coincident with decided salivation. In dog D the nasal discharge was decided, although salivation was not observed.

It can hardly fail to strike anyone that the doses required to produce salivation in these dogs are much larger than those usually required in the case of man. The dose required in the dog is, however, perhaps not nearly so great as Table I. makes it appear; for it must be remembered that a dog cannot, like a man, tell us when it feels unusual moisture in the mouth. When, therefore, we have noted salivation as having been produced, it has only been when the salivation had become very marked, giving rise to unusual wetness of the mouth, or to a stream of saliva flowing from it.

In all the dogs, excepting dog D, the appetite became much impaired, and the breath remarkably fœtid. In dogs A, C, and E the mucous membrane of the mouth became ulcerated. Mere sponginess of the gums was never observed.

All the dogs, with the exception of dog D, became much emaciated. During the very decided action of the drug, blood appeared in the fæces of all the dogs, excepting dog E. Profuse diarrhœa was produced in all the dogs without biliary fistulæ; it was slight in the little dog D, while it was entirely absent in the other two dogs with fistulæ, although these, like all the other dogs, were killed by corrosive sublimate. During the exhibition of the drug, the fæces in dog A changed from a light to dark brown, brownish yellow, and greenish brown; in dog B they changed from brown to greenish brown, greenish yellow, and slate-brown; while in dog C they hardly underwent any change in colour. In dogs D and E there was no change in the colour, while in dog F they changed from a clay to a slate-colour: this dog, like the two previous ones, had a biliary fistula.

Appearances found on Dissection.

In all the dogs the mucous membrane of the stomach was found healthy. In all there were numerous bright red vascular patches found on the mucous membrane of the small intestine, extending from the pylorus to the ileo-colic valve. In dog B there were patches of lymph on the inner surface of the mucous membrane of the ilium. In dogs C and F this redness was most marked in the duodenum, but the orifice of the common bile-duct was not redder than the other portions of the duodenum. In all the dogs, except

dog B, the mucous membrane of the large intestine was streaked with bright red lines running longitudinally throughout its entire length.

In all the dogs, except dog D, there was unusual vascularity of the pancreas, but in none was there any abnormal appearance of the salivary glands.

In no case did the liver present any unusual appearance.

These facts show that on the dog mercury has the same action as it exerts on man.

Results of the Experiments made on Dogs with Biliary Fistulæ to determine the action of Mercury as a Cholagogue.

During the two years over which the Committee's inquiries extended, forty-one dogs were subjected to the operation for establishing a biliary fistula. Of these, four died during its performance from the effects of chloroform. In four others the operation was not proceeded with after opening the peritoneum, in consequence of the impossibility of bringing the fundus of the gall-bladder in contact with the abdominal wall. The operation was completed in thirty-three cases, but from various causes, which the Committee consider it unnecessary to detail minutely, satisfactory observations could only be carried on in nine dogs. These have been numbered consecutively from one to nine, but it has been thought better to arrange the numerous observations made upon them according to the preparation of mercury employed.

Observations with Pil. Hydrargyri.

The first dog (No. 1) in which a biliary fistula was successfully established by the Committee was a healthy retriever about eighteen months old, weighing 18·5 kilogrammes, for which we are indebted to Mr. Nunneley of Leeds. The operation was performed on the 29th of May, 1867. The wound in the abdominal wall healed rapidly. Shortly after the operation the fæces became clay-coloured. The general health of the animal was excellent when on the 10th of June the apparatus for collecting the bile was applied, and the observations recorded in the following Table (Table II.) were commenced.

As the metrical system of weights is used in all the Tables with regard to everything except the doses of drugs, it may be of service to remind the English reader that—

1 gramme = 15·434 grains, 28·34 grammes = 1 ounce, 1 kilogramme = 2·2 pounds.

Table II.—First Series of Observations on Dog 1. Daily amount of Bile secreted without Mercury.

1	2	3				4			5			6		
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted		
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.
1867.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grms.	grm.
June 11.	18·5	None.	567	170·1	283·5	150·4	8·843	1·221	8·12	0·478	0·066	65·5	3·85	0·53
„ 12.		„	„	„	„	125·0	8·400	1·355						
„ 15.		„	„	„	„	75·7	5·791	0·836	4·09	0·313	0·045	32·9	2·52	0·36
„ 17.		„	„	„	„	121·8	6·954	1·280						
„ 18.		„	„	„	„	115·0	7·290	1·345						
„ 19.		„	„	„	„	130·7	8·456	1·520						
Mean						119·76	7·622	1·259	6·47	0·412	0·068	52·18	3·32	0·548

Note.—The amount of dry food consumed daily during the above period amounted to 22·5 grammes.
„ „ „ for each kilogramme of dog amounted to 12·3 grammes.

The above series of observations was undertaken with a view to ascertain the average amount of bile secreted daily previous to the administration of mercury to the animal. It was thought necessary to collect the bile for six consecutive days before calculating its average daily amount; for, as is evident from the Table, the secretion was very inconstant. Thus on June 15th the quantity secreted was only about a half of what it was upon the 11th.

In the above Table three days (the 13th, 14th, and 16th) have been omitted, owing to a portion of the bile having been lost. This resulted from slipping of the apparatus. Despite every care in its adjustment, it was sometimes so shifted by the movements of the animal that the canula was dragged out of the fistula, and the bile consequently lost.

The average daily amount of bile secreted during the six days was 119·76 grammes of fluid bile, 7·622 grammes of bile solids, and 1·259 gramme of bile salts*. The daily amount of food consumed during the whole period was uniform. This was due to the fact that for some days previous to the commencement of the bile-collections the dog was offered an excess of food; the amount consumed was estimated, and this amount was given on subsequent days, and always entirely eaten by the animal. With a view to assimilate all the Tables, a column for water is introduced, although in this case none was given.

In this and all the following Tables, the amount of fluid bile, bile solids, and salts secreted is estimated with regard to each kilogramme-weight of the animal, and each 100 grammes of dry food consumed by it. In columns 5 and 6 of the foregoing Table these estimates are made on the days when the maximum and minimum quantities of bile were secreted; and the average quantities given at the foot of these columns are, in this and all the subsequent Tables, estimated from the average quantities of columns 2, 3, and 4. Columns 5 and 6 have a special physiological interest, and will be afterwards referred to at length. For the present the attention of the reader need not be directed to column 5, for the experience of the Committee has shown that there is no relation between the amount of bile secreted and the weight of the animal; the relation between the amount of food consumed and the quantity of bile secreted is not a very close one either (as the foregoing Table is sufficient to show), yet in some cases it seems to be such as to render necessary its being taken into account when the influence of any agent upon the biliary secretion is under consideration †.

During all the observations on this animal, however, the same amount of food was taken daily; therefore any variation in the biliary secretion cannot be ascribed to variation in the diet, so that the relation between the secretion of bile and amount of food may in this case for the present be disregarded.

On the 19th of June it was found necessary to discontinue the observations, as the pressure of the apparatus had caused ulceration of the skin over the sternum, and the fistula had assumed a very irritable appearance. The wound having healed, and the fistula become more healthy, the observations were resumed on the 28th of June, and continued for other six consecutive days.

The results are given in the following Table:—

* By the term bile *salts* in this and all subsequent Tables is meant the *inorganic* solids of the bile left after its incineration.

† To give completeness to the Tables the absolute amount of dry food taken daily or on some particular day, together with the amount consumed per kilogramme of dog, has been given.

TABLE III.*—Second Series of Observations on Dog 1. Daily amount of Bile secreted without Mercury.

1	2	3				4			5			6		
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted		
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.
1867.						grms.	grms.	grms.	grms.	grm.	grm.	grms.	grms.	grms.
June 29.	16·8	None.	567	170·1	283·5	106·2	3·865	1·15						
„ 30.		„	„	„	„	148·0	†	†						
July 1.		„	„	„	„	117·5	4·31	1·116						
„ 2.		„	„	„	„	185·1	6·60	2·010	11·01	0·392	0·119	80·6	2·87	0·87
„ 3.		„	„	„	„	81·6	2·978	0·824	4·85	0·177	0·049	35·5	1·29	0·35
„ 4.		„	„	„	„	149·5	5·80	1·615						
Mean						131·31	4·71	1·343	7·82	0·28	0·079	57·21	2·05	0·58

The amount of dry food consumed daily during the above period amounted to 229·5 grammes.
„ „ „ for each kilogramme of dog amounted to 13·6 grammes.

* In columns 5 and 6 the maximum, minimum, and mean quantities are calculated; the last, however, are estimated from the mean quantities of column 4.
† Not determined.

This second series of observations was again directed to ascertain the normal secretion of bile, in the hope that the secretion would become more constant; the Table, however, shows that this expectation was not realized, the variation in the daily quantity of bile was indeed even greater. Owing to the experience gained in this experiment, all subsequent observations directed to ascertain the normal secretion of bile previous to the administration of a drug were seldom prolonged beyond four or five days.

Table III. shows that the average amount of fluid bile secreted daily during this series of observations was slightly above the average amount secreted during those in Table II.; but it shows that there was a great diminution in the bile solids. The average quantity during the first series was 7·622 grammes, during the second series only 4·71 grammes. This was entirely due to a falling off in the amount of the organic constituents of the bile; for the Tables show that during the second series the inorganic solids (*bile salts*) were somewhat greater in amount than they were during the first series of observations. The animal had lost weight to the extent of 1·7 kilogramme, but was nevertheless in excellent health generally, although the irritable state of the fistula rendered necessary an interruption of the observations until the 8th of July.

As it seemed impossible to obtain a better standard of comparison than was afforded by Table III., it was resolved to commence the administration of mercury. Table IV. shows the results.

Five grains of Pil. Hydrargyri were given as one dose daily during eight days; the pill was always given twenty-four hours previous to the collection of the bile.

On July 11th, the apparatus having shifted, the bile escaped. On the other seven days, however, the collections were perfect, and the results show that the administration of the drug was accompanied by slight diminution (3·71 grammes) in the average quantity of fluid bile secreted daily, and a slight augmentation (0·45 gramme) in the average quantity of bile solids. This slight increase in the bile solids cannot be regarded as a proof of the power of blue pill to increase the biliary secretion, when the extreme variations of the secretion in this case are taken into account. In favour

of the idea it may, indeed, be alleged that on July 14th (Table IV.) more fluid and solid bile was secreted under the influence of blue pill than had been secreted on any day without it; but as a counterpart to this it can be said that on July 17th (Table IV.) the amount of fluid and solid bile was less than it had ever been on any previous day. On the whole, therefore, it may be concluded that in this case there was no evidence that the administration of blue pill affected the biliary secretion.

TABLE IV.*—Third Series of Observations on Dog 1. Amount of Bile secreted in twenty-four hours when 5 grs. of Pil. Hydrargyri were given daily.

1	2	3				4			5			6		
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted		
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids	Bile salts.	Fluid bile.	Bile solids.	Bile salts.
1867.						grms.	grms.	grms.	grms.	grm.	grm.	grms.	grms.	grm.
July 9.	15	None.	567	170·1	283·5									
„ 10.		„	„	„	„	100	4·27	1·10						
„ 11.		„	„	„	„									
„ 12.		„	„	„	„	89	3·729	1·023						
„ 13.		„	„	„	„	170·6	6·19	1·74						
„ 14.		„	„	„	„	204·0	8 9	2·29	13·6	0·39	0·152	88·8	3·52	0·99
„ 15.		„	„	„	„	139 0	5·86	1·52						
„ 16.		„	„	„	„	127·6	5·13	1 50						
„ 17.		„	„	„	„	67·0	2 86	0·73	4·46	0·19	0·042	29·19	1·246	0·31
Mean						127·6	5·1 6	1·38	8·50	0·344	0·09	55·6	2·24	0·601

NOTE.—The amount of dry food consumed daily during the above period amounted to 229·5 grammes.
„ „ „ for each kilogramme of dog amounted to 15·27 grammes.

* In columns 5 and 6 the maximum, minimum, and mean quantities only are calculated. The last, however, are estimated from the mean quantities of column 4.

The above-mentioned doses of blue pill did not purge the animal.

On July 17th the observations were interrupted on account of renewed ulceration over the sternum by the pressure of the apparatus. At that date the animal was in excellent health.

The observations were resumed after an interval of six days. The results are given in the following Table:—

TABLE V.†—Fourth Series of Observations on Dog 1. Amount of Bile secreted in twenty-four hours when 5 grs. of Pil. Hydrargyri were given daily.

1	2	3				4			5			6		
Date.	Weight of dog.	Amount of food, in grammes.				Quanty of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted		
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.
1867.						grms.	grms.	grm.	grms.	grms.	grms.	grms.	grms.	grms.
July 23.	15	None.	8·46	282	225·6	231·9	7·55	lost.						
„ 24.	„	„	„	„	„	56·7	1·61	lost.						
„ 25.	„	„	„	„	„	95·0	2·86	0·931						
„ 26.	„	„	„	„	„	49·1	1·73	lost.						
„ 27.	„	„	„	„	„	38·2	1·41	0·443						
„ 28.	„	„	„	„	„	175·0	4·88	1·66						
„ 29.	14·9	„	„	„	„	69·3	2·64	0·691						

† In this and all subsequent Tables the amount of medicine said to be given on any day was always given during the twenty-four hours *previous* to the bile collection of the same date.

Pil. Hydrargyri was again given. Extraordinary variations occurred in the amount of bile obtained during its exhibition, and the quantities appear to show that the secretion of bile was diminished; but they are in truth rendered valueless by the circumstance that a considerable quantity of bile was separated by the kidneys, owing, most probably, to its free exit by the fistula having been interfered with. The animal was never purged until July 30th, when it twice passed a considerable quantity of liquid fæces. Although it did not lose weight to any notable extent during the period embraced by Table V., its strength diminished. In order that the dog might rally, the observations were suspended, and a more liberal diet allowed. It grew gradually weaker, however, and died on the 5th of August. On dissection a layer of recent lymph was found over the whole surface of the peritoneum. The cause of the peritonitis was not evident *.

Observations with Calomel.

The second dog (No. 2), with a biliary fistula, was a full-grown half-bred collie, weighing 15·6 kilogrammes. The operation was performed on the 5th of September, 1867. The wound healed perfectly, and collection of the bile was begun on the 20th of September. The general health of the animal was, however, indifferent; its appetite was uncertain, and its general strength feeble. When the apparatus was applied, the animal appeared to be much distressed by its weight, and by the constriction of the thorax and abdomen, which its proper application rendered necessary. After the operation the fæces became clay-coloured.

During seven days, from September 21st to 27th inclusive, observations were made with a view to determine the normal secretion of bile: the results are given in the following Table (Table VI.):—

Table VI.—First Series of Observations on Dog 2. Daily amount of Bile secreted without Mercury.

1	2	3				4			5			6		
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted		
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.
1867.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grms,	grms.
Sept. 21.	15·6	None.	561	None.	None.	130	7·29	1·41	8·333	0·467	0·09	230·0	12·9	2·51
„ 22.		„	561	„	„	81	4·48	0·907						
„ 23.	...	Not a State "scar ken."	ccura ment cely	tely no in book any foo	ted. is d ta-	94·15	6·072	1·205						
„ 24		None.	225·6	None.	None.	94·70	5·750	1·01						
„ 25.	15·6	„	282	„	310·2	78·80	5·92	1·25	...	...	...	73·9	5·60	1·18
„ 26.		„	197·4	„	225	62·50	5·70	1·08						
„ 27.		Has onl	y tak	en a litt	le milk	35·50	1·99	0·436	2·27	0·12	0·027			
Mean for seven days						82·46	5·31	1·012	5·27	0·34	0·066			

Note.—On the 25th September the dry food consumed amounted to 105·7 grammes, or 6·7 grms. per kilog. of dog; on the 21st, 56·4 grms., or 3·6 grms. per kilog. of dog.

In this Table, as well as in several others, it will be observed that the amount of bile collected was greater on the first than on other days—a rule, however, by no means invariable. The occurrence was probably due to the canula having permitted a freer exit to the bile than the fistulous opening

* For further observations on the action of Pil. Hydrargyri see Tables IX. and X.

which the contraction of the recti abdominis always tended to close. At first, therefore, after the introduction of the canula, a large quantity of bile pent up in the ducts may have escaped, or the larger quantity may have been due to increased biliary secretion.

The average quantity of bile secreted daily by dog 2 during the seven days embraced by Table VI. was of fluid bile 82·46 grammes, of bile solids 5·31 grammes, of bile salts 1·042 gramme. During the whole period the animal took a very variable quantity of food; on two days the amount was not accurately recorded; the average quantity of dry food consumed daily could not therefore be estimated. The biliary secretion was, when compared with the amount of food, extremely variable, however, as column 6 of the Table suffices to show.

The general health of the animal had not materially suffered by the continued application of the apparatus, although it at first occasioned so much distress.

It was now decided to observe the effects of calomel. Table VII. (p. 209) gives the results.

During the six days embraced by Table VIII. calomel was given internally in varying doses. The effect of the medicine upon the general health of the animal was very decided; it grew daily weaker and thinner, it lost its appetite, had attacks of vomiting on October 2nd and 3rd, and died on October 5th, apparently from inanition. Purgation, fœtor of the breath, or ulceration of the gums were never produced by the drug, nor was there any evidence of salivation.

On October 2nd the bile was lost, and on the 3rd, two days before the death of the animal, and when it took no food, only 2·2 grammes of bile were secreted. An average has been taken from the first four days during which the animal took food. The average quantity of fluid bile secreted during these four days was 60·02 grammes.

The average quantities of bile solids and salts have not been estimated seeing that they were not ascertained on September 29th. The Table shows that under the action of the calomel less bile was secreted than there was previous to its exhibition; but as the amount of calomel given had seriously, indeed fatally, injured the health of the animal, it was determined to try in the next case the effect of minute and frequently repeated doses.

Dog 3 was a young healthy retriever, weighing 12·9 kilogrammes. The operation for biliary fistula was performed on the 13th of October, 1867. A few hours afterwards the dog pulled the india-rubber tube out of the fistula, and the external opening of the fistula closed, so that on October 15th the fistulous opening had to be reestablished by an incision. The wound in the abdominal wall healed satisfactorily, the fæces were clay-coloured, and the animal was in excellent health when the collection of bile was begun, October, 26th 1867. It was decided to observe the effects of very small doses of calomel ($\frac{1}{12}$ of a grain) frequently repeated. The bile was collected on four successive days previous to, and on four consecutive days during the exhibition of the drug without any break between the two series. Table VIII., p. 209, gives the results of both series of observations.

During the four days previous to the administration of the calomel the animal secreted daily on an average 70·62 grammes of fluid bile, 3·792 grammes of bile solids, and 0·83 gramme of bile salts. The health of the animal during these days was excellent.

TABLE VII.—Second Series of Observations on Dog 2. Daily amount of Bile secreted when Calomel was given.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			Amount of Calomel given.
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1867.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grms.	grms.	
Sept. 28.	14·3	None.	846	None.	None.	61·6	3·54	0·67	4·307	0·24	0·46	72·8	4·18	0·79	2 grains three times in the day=6 grains.
„ 29.	„	„	253·8	„	112·8	7·3	..	...	...	...	...	...	...	...	2 grains in the day =2 grains.
„ 30.	„	„	141·0	„	253·8	85·7	5·69	1·11	5·99	0·39	0·07	164·2	10·9	2·12	2 grains three times in the day=6 grains.
Oct. 1.	...	„	253·8	„	None.	65·5	3·76	0·85	...	...	...	...	...	...	2 grains four times in the day=8 grains.
„ 2.	...	„	282	„	„	Lost.	...	...	...	...	...	...	...	...	2 grains six times in the day=12 grains.
„ 3.	12·24	„	none.	„	„	2·2	...	...	...	...	...	...	...	...	2 grains twice in the day=4 grains.
Mean quantity during first four days						60·02									

NOTE.—On 28th Sept. the dry food consumed amounted to 84·6 grammes, or 5·9 grammes per kilog. of dog.
30th „ „ „ „ „ „ 77·55 grms., or 5·30 grms. per kilog. of dog.

TABLE VIII.—Observations on Dog 3. Daily amount of Bile secreted before and after Calomel was given.

1	2	3				4			5			6			7
Oct. 26.	12·9	None.	564	None.	338·4	91	4·83	1·19							Before calomel was given.
„ 27.	...	„	„	„	„	111	6·14	1·26	8·60	0·476	0·097	78·7	4·354	0·839	
„ 28.	...	„	„	„	„	22	1·16	0·27	1·70	0·080	0·002	15·6	0·822	0·191	
„ 29.	...	„	„	„	None.	58·5	3·04	0·60							
Mean of the above observations			564	...	253·8	70·62	3·792	0·83	5·47	0·293	0·064	58·9	3·165	0·692	
Oct. 30.	12·2	None.	none.	None.	None.	36	1·88	0·45	2·96	0·154	0·036	...	...	...	Seven pills, each containing one-twelfth of a grain of calomel, were given one at a time, with an hour's interval between each.
„ 31.	...	„	„	„	„	89·9	4·79	1·15	...	...	...	...	...	...	Seven pills as above.
Nov. 1.	...	„	„	„	338·4	108·5	5·76	1·36	8·89	0·472	0·111	...	...	...	Fourteen pills as above.
„ 2.	...	„	„	„	None.	46·9	2·51	0·6	...	...	...	...	...	...	Six pills as above.
Mean of the second series of observations						70·32	3·732	0·89	5·76	0·305	0·072				

NOTE.—On October 26th, 27th, and 28th, the dry food consumed amounted to 141 grammes, or 10·9 grms. per kilog. of dog; the mean quantity consumed daily on the first four days amounted to 119·8 grms., or 9·13 grms. per kilog. of dog.

The amount of food consumed when the mercury was given was so small (taken on one day only) that no calculation has been made from it.

On October 30th seven pills, each containing $\frac{1}{12}$ of a grain of calomel, were given with an hour's interval between each. On October 31st seven pills, on November 1st fourteen pills, and on November 2nd six pills were administered in the same way as above mentioned.

The effect on the general health was very marked. Soon after the administration of the drug was begun the appetite failed, and the animal took no food of any kind during three of the four days. The strength became rapidly exhausted, and the animal died on November 3, apparently from inanition. No salivation, fœtid breath, ulceration of gums, or purgation were produced by the medicine.

The average of the second series of observations shows that during the four days on which the calomel was given the secretion of bile was not influenced. It was almost exactly the same in the second as during the first period, thus distinctly showing that the calomel cannot be said to have affected it at all. It is also to be observed that although during the second four days the animal took food only once, the amount of bile secreted was on an average very nearly the same as during the first four days when it ate well. This might at first sight be considered as supporting the notion that mercury increases the biliary secretion. But were it true that in the present case the mercury had kept up the secretion notwithstanding the diminution in the food, then certainly it ought to increase the secretion when a due supply of food is taken; for it cannot be held that the influence of food is anything but highly favourable to the secretion. The results given in Table IX. will show that such is not the case.

Dog 4 was a healthy collie, about eighteen months old, weighing 19 kilogs. The operation for biliary fistula was performed on the 19th of October, 1867. The wound in the abdominal wall healed slowly. As the fistulous opening was very irritable, the canula was not introduced. Instead of the canula and india-rubber bag previously employed, a sponge was used to collect the bile; it was secured in a tin box below the fistulous opening. The fæces became clay-coloured soon after the fistula was established.

The general health of the animal was excellent when the observations recorded in Table IX. p. 211, were begun.

The bile was collected for five consecutive days previous to the administration of mercury, in order to ascertain the average amount secreted daily. This was: of fluid bile 67·1 grammes, of bile solids 3·592 grammes, of bile salts 0·842 gramme. At the end of this period the dog was in excellent health.

On November 8th the administration of mercury was begun. During the twenty-four hours previous to the collection of bile on that day, ten pills, each containing one-twelfth of a grain of calomel, were given, one pill at a time, with an hour's interval between each. On the next day twelve such pills were given. On November 10th ten grains Pil. Hydrargyri were administered in one dose. On the 11th and 12th no mercury was given. On the 13th the ten grains of Pil. Hydrargyri were repeated. On the 14th nine calomel pills were given as above; and on the last day of the observations the mercury was withheld.

During the five days on which calomel or blue pill was administered in the above modes, the amount of bile secreted was diminished to nearly a half of what it was in the period preceding the administration of the mercury; and this, although nearly as much food was consumed during as before the exhibition of the drug. Moreover, during the second period, the average amount of bile secreted was, on the whole, greater on the days when no mercury was

Table IX.—Observations on Dog 4. Daily amount of Bile secreted before and after Calomel and Pil. Hydrargyri were given.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			Amount of Mercury given.
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1867.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grms.	grm.	
Nov. 3.	19	338·4	282	112·8	338·4	71·2	3·84	0·85							Before mercury was given.
„ 4.	...	„	„	„	„	61·9	3·34	0·81							
„ 5.	...	„	564	56·4	„	88·9	4·78	1·14	4·67	0·251	0·06	50·85	2·703	0·652	
„ 6.	...	„	282	„	„	72·0	3·80	0·90							
„ 7.	...	„	„	„	„	41·5	2·23	0·514	2·18	0·117	0·027	28·308	1·521	0·350	
Mean		338·4	333	78·96	338·4	67·1	3·592	0·842	3·53	0·146	0·014	40·13	2·148	0·503	
Nov. 8.	18·3	338·4	282	56·4	338·4	*76·0	4·13	1·01	4·15	0·225	0·055	51·84	2·817	0·688	Ten pills given, each containing one-twelfth of a grain of calomel; one pill every hour.
„ 9.	...	„	„	„	„	*47·0	2·54	0·56	...	...	...	...	...	...	Twelve pills as above.
„ 10.	...	„	„	„	„	*12·5	0·06	0·01	0·68	0·003	0·0005	8·525	0·018	0·006	10 grains Pil. Hydrargyri given.
„ 11.	...	„	„	„	„	45·0	2·41	0·54	...	...	...	...	...	...	No mercury given.
„ 12.	...	„	„	„	„	58·0	3·07	0·754	...	...	...	...	...	...	No mercury given.
„ 13.	...	„	„	„	„	*24·0	1·33	0·34	...	...	...	...	...	...	10 grains Pil. Hydrargyri given.
„ 14.	...	„	„	„	„	*17·8	1·00	0·26	...	...	...	...	...	...	Nine pills, each containing one-twelfth of a grain of calomel given; one pill every hour.
„ 15	...	„	„	„	„	45·0	2·40	Lost.	...	...	...	...	...	...	No mercury.
Mean of the five days (marked*) on which mercury was given.		338·4	282	56·4	338·4	35·16	1·812	0·436	1·93	0·099	0·023	24·18	1·23	0·29	

Note.—The average amount of dry food consumed during the first period amounted to 167·2 grammes, or 8·8 grammes per kilogramme of dog. The average amount of dry food consumed during the first period amounted to 146·6 grammes, or 8·01 grms. per kilogramme of dog.

given than on the other days. No purgation or any signs of specific action were produced by the mercury; but shortly after its first administration the strength of the animal began to decline. Sores, produced by the pressure of the apparatus, formed upon the back, in consequence of which the observations were interrupted on November 15th. The appetite failed, and the animal became so much emaciated that it was killed on the 28th of November.

It is evident that in this case the mercury diminished the biliary secretion, and it is remarkable that it did so without impairing the appetite, and without producing purgation.

In the foregoing experiments purgation had never been produced by the mercurials while the bile was being collected; it seemed, therefore, desirable to ascertain the effect upon the biliary secretion of purgative doses. This was done in the following experiment.

Dog 5 was a strong collie, twelve months old, weighing 16·7 kilogrammes. The operation for biliary fistula was performed on the 2nd of June, 1868. The fistula became satisfactorily established, but on June 28th the dog escaped. It was reobtained on the 11th of July. The fistulous opening had closed, the dog was jaundiced, conjunctiva and skin yellow, urine loaded with bile. As the fæces were, however, clay-coloured, an attempt was made to open the fundus of the gall-bladder. This was found distended with a thick, gelatinous, colourless fluid like white of egg. About ten ounces of this fluid at once flowed from the opening. It was not in the least tinged with bile. The glairy fluid continued to drop from the opening for several hours, after which the bile began to flow, and continued to do so.

In ten days every symptom of jaundice had disappeared, the fæces were clay-coloured, and the wound was sufficiently healed to permit of observations being begun. In Table X., p. 213, are recorded the results obtained before, during, and after purgative doses of calomel and Pil. Hydrargyri were given.

The bile was collected perfectly on six days in order to ascertain the normal secretion. The average daily quantity during this period was 357·4 grammes of fluid bile, 13·11 grammes bile solids, and 3·12 grammes of bile salts. During the first four days the dog was in excellent health. On July 26th it was seized with a smart attack of diarrhœa. On that day both the fluid and solid portions of the bile were diminished. The diarrhœa did not recur after the 26th. On the 27th the collection of bile was rejected, owing to urine having mingled with it. On the 28th it had risen to a little above the average quantity.

Twenty-four hours previous to the collection of the bile on the 29th, ten grains of blue pill were administered. During the three succeeding days ten grains of calomel were given daily in one dose on each occasion twenty-four hours previous to the bile collection. The dose of blue pill and the first dose of calomel produced slight purgation, while decided purgation followed the administration of the two last doses. There was a marked diminution in the biliary secretion during this period, the average daily amount being: of fluid bile 272·67 grammes, of bile solids 7·78 grammes, of bile salts 2·06 grammes. It will be seen from the Table that this diminution is quite as marked in the solid as in the fluid bile.

The high amount which the fluid bile attained when ten grains of blue pill were given might be supposed to indicate an increase in the secretion. The variations in the amount of solid constituents of the bile are, however, those

TABLE X.—Observations on Dog 5. Daily amount of Bile secreted before and after purgative doses of Mercury were given.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			Observations.
	Kilogs.	Water.	Milk.	Bread.	Liver.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1868.						grms.	grms.	grms.	grms.	grm.	grm.	grms.	grms.	grm.	
July 22.	16·7	566	566	226·4	906·8	412	16·06	3·21	24·67	0·961	0·192	102·7	4·00	0·800	Dog in good health.
,, 23.	16·6	,,	,,	,,	,,	331·8	13·20	2·91	...	...	...	...	...	...	Dog in good health.
,, 24.	16·4	367·9	226·4	,,	,,	375·4	9·20	3·26	...	...	...	...	...	...	Dog in good health.
,, 25.	16·2	566	566	,,	,,	379·1	14·78	3·07	...	...	...	...	...	...	Dog in good health.
,, 26.	16·0	,,	,,	,,	665·9	282·7	12·80	2·63	17·66	0·80	0·167	81·8	3·74	0·775	Decided diarrhœa.
,, 27.	...	...	...	...	...	Lost.	...	...	...	...	...	...	...	...	Diarrhœa has ceased.
,, 28.	16·3	,,	566	212·2	906·8	363·7	12·62	3·60	...	...	...	...	...	...	Dog in good health.
Mean...	16·36	532·9	509·4	221	866·6	357·4	13·11	3·12	21·8	9·801	0·190	92·9	3·49	0·811	No mercury given during the above period.
July 29.	15·9	566	495·2	198·1	807·6	390·2	9·59	2·77	23·9	0·603	0·174	110·2	2·7	0·782	10 grains blue pill given twenty-four hours previous to the collection of bile to-day; slight purgation.
,, 30.	15·7	,,	523·5	183·9	906·8	249·7	7·71	1·97	...	...	...	...	...	...	10 grains calomel given as above; slight purgation.
,, 31.	...	,,	254·7	84·9	424·5	229·0	6·89	1·74	...	...	...	...	...	...	10 grains calomel given as above; decided purgation.
Aug. 1.	15·4	,,	566	226·4	566	221·8	6·91	1·77	14·4	0·450	0·114	68·9	2·15	0·54	10 grains calomel given as above; decided purgation.
Mean of the above 4 days	15·66	566	459·8	173·3	676·2	272·67	7·78	2·06	17·4	0·496	0·131	89·2	2·54	0·674	
Aug. 2.	...	566	396·7	141·7	906·8	293·9	8·17	Lost.	...	...	...	...	...	...	No mercury given.
,, 3.	15·2	,,	253·8	,,	,,	297·5	7·59	2·43	19·4	0·499	0·15	93·3	2·38	0·76	No mercury given.

NOTE.—From July 22 to July 28 the mean amount of dry food consumed daily was 384·6 grammes, or 23·4 grammes per kilogramme of dog. From July 29 to August 1 the mean amount of dry food consumed daily was 305·3 grammes, or 19·23 grammes per kilogramme of dog.

which are of paramount importance in the present inquiry, and the diminution of these on the 29th is unmistakeable.

The bile was finally collected for two days, August 2nd and 3rd, on which no mercury was given. There was no purgation on these days, and the amount of bile secreted suddenly increased. Though the amount was not nearly so great as before mercury was given, it was nevertheless much above the last two days during its administration.

Previous to the exhibition of mercury the fæces were of a clay-colour, mixed with slate-coloured patches. During and on the two days after the mercury was given they were more uniformly slate-coloured. During the whole experiment the health of the animal was excellent, neither the diarrhœa nor the mercurial purgation seemed to affect it.

This series of observations is most conclusive as to the influence of purgative doses of calomel upon the biliary secretion. Under their influence there was a steady diminution in the secretion, and the moment the administration of the drug was suspended, the secretion underwent an increase.

It is important to observe that in this case purgation, whether spontaneous as on the 26th, or as the result of mercurials, diminished the secretion of bile. Other observations will be given further on (see Tables XVII., XVIII., and XIX.), which show that when induced by other drugs it likewise diminishes the biliary secretion.

The amount of bile secreted by this dog was very large, greater in proportion to the weight of the animal than in any other case. At first we were inclined to suppose that this might be due to the animal being fed upon *liver*; but in the case of dog 6, to be described presently, the amount secreted per kilogramme of dog was nearly as great, although the animal ate no liver; and the amount per 100 grammes of dry food was very much greater.

In the foregoing experiment the dose of blue pill given, although it diminished the bile solids, increased that of the bile fluid. It was important to ascertain whether or not the same result would be obtained on another trial. In another dog (No. 7) ten grains of blue pill were given on one day, and fifteen grains on the day following. Slight purgation was produced by the first dose, decided purgation by the second. On the day preceding the administration of the mercury, the amount of fluid bile was 173·9 grammes, of bile solids 9·35 grammes. The bile was lost on the day that the first dose of blue pill was given, but on the next day it had fallen to 119·9 grammes, and the bile solids to 7·5 grammes.

On both days the animal consumed about the same quantity of food. It is therefore clear that the observation recorded in the case of dog 5 on the 29th of July cannot be held as indicating the power of blue pill to increase the fluid portion of the bile; while this observation on dog 7 only confirms the result in the case of dog 5, viz. that a purgative dose of blue pill diminishes the amount of bile solids secreted.

Results of the preceding observations on the Cholagogue Action of Pil. Hydrargyri and Calomel.

1. Pil. Hydrargyri, when given in doses which did not produce purgation, caused no increase of the biliary secretion (Tables IV. and IX.).

2. Pil. Hydrargyri, when given in doses which produced purgation, diminished the biliary secretion (Table X., and non-tabulated observations on dog 7).

3. Calomel, given in doses of $\frac{1}{12}$ of a grain from six to fourteen times a day,

TABLE XI.—Observations on Dog 6. Daily amount of Bile secreted before and after Corrosive Sublimate was given.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			Amount of Corrosive Sublimate given.
	Kilogs.	Water.	Milk.	Bread.	Meat.	Fluid bile.	Bile solids.	Bile salts.	Fluid. bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1868.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grms.	grms.	
Mar. 9.	5·1	None.	567	113·4	None.	105	4·158	0·934	20·58	0·815	0·183	142·3	5·64	2·48	Four-fifths of a grain of corrosive sublimate were given at 1 o'clock P.M., immediataly after the collection of bile was made on the 11th, and another dose of four-fifths of a grain was given at 9 o'clock A.M. on the 12th, and the last collection of bile was made at 1 P.M. on the same day.
,, 10.	,,	,,	141·6	None.	,,	106·5	4·313	0·969	20·88	0·845	0·190	748·0	30·4	6·84	
,, 11.	,,	,,	56·7	,,	225·8	101·7	4·062	0·942	20·52	0·796	0·184	167·8	6·9	1·51	
,, 12	4·93	,,	850·5	56·7	None.	78	3·178	0·717	15·67	0·638	0·142	65·5	2·67	0·60	

NOTE.—On March 9th the dry food consumed amounted to 73·7 grammes, or 14·45 grammes per kilog. of dog; on the 10th, 14·16 grammes, or 2·776 grammes per kilog. of dog; on the 11th, 62·37 grammes, or 12·22 grammes per kilog. of dog; on the 12th, 119·07 grammes, or 23·9 grammes per kilog. of dog.

TABLE XII.—First Series of Observations on Dog 7. Daily amount of Bile secreted before Corrosive Sublimate was given.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			
	Kilogs.	Water.	Milk.	Bread.	Tripe.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1868.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grm.	grm.	
May 30.	27·4	846	564	225·6	1353·5	136·3	6·97	1·22	4·97	0·25	0·044	26·52	1·31	0·23	
,, 31.	...	,,	,,	,,	,,	Lost.									
June 1.	...	,,	,,	,,	,,	132·8	not detd.	not detd.							
,, 2.	...	,,	,,	,,	,,	114·0	6·04	0·97	4·16	0·22	0·039	21·55	1·139	0·17	
,, 3.	...	,,	,,	,,	,,	125·5	6·28	0·91							
Mean	27·4	846	564	225·6	1353·5	127·15	6·43	1·03	4·64	0·23	0·037	23·99	1·21	0·19	

NOTE.—During the whole of this period the dry food consumed amounted to 530·1 grammes, or 19·34 grammes per kilog. of dog.

and in doses of two grains from two to six times a day, did not produce purgation or increase the biliary secretion (Tables VII., VIII., and IX.).

4. Calomel, when given in doses which produced purgation, diminished the biliary secretion (Table X.).

Observations with Corrosive Sublimate.

Dog 6, a retriever, six months old, weighing 5·1 kilogrammes, was operated on for biliary fistula, February 26th, 1868. The recovery was in this case speedy and perfect. Soon after the operation the fæces became clay-coloured. The health of the animal was excellent, and was not appreciably injured by the operation or the effects of the fistula.

Table XI. p. 215, gives the results of the observations, with corrosive sublimate on four consecutive days, three previous to, and one during the administration of the drug.

During the three days previous to the administration of the mercury, the secretion of fluid and solid bile was remarkably constant, and this notwithstanding great variation in the amount of food taken. The mean quantity was, of fluid bile 105·4 grammes, of bile solids 4·144 grammes, of bile salts 0·948 gramme. The constancy in the secretion rendered the case a very valuable one for observing whether or not it was affected by the drug. On the fourth day two doses of $\frac{4}{5}$ of a grain of corrosive sublimate were injected under the skin. The first dose was given at 1 P.M. on the 11th, immediately after the collection of bile had been made on that day. The second dose was given at 9 A.M. on the 12th, and the last collection of bile was made at 1 P.M. on the same day. The amount of fluid bile on this the fourth day was 78 grammes, of bile solids 3·178 grammes, of bile salts 0·717 gramme. Twenty hours after the first dose of the drug was given, a slight discharge of mucus from the nostrils was observed, and a patch of semisolid clay-coloured fæces mingled with a few drops of blood was found upon the floor. Two hours following the administration of the second dose, the animal was observed to be exceedingly weak; it was in a state of constant tremor, and staggered on attempting to walk. At 1 P.M. on the 12th, four hours after the second dose of mercury was given, the last collection of bile was made; at that time the nasal discharge had become more marked. There was no apparent salivation, nor was the breath fœtid. The animal was last seen alive at 5.30 P.M. on the 12th, eight and a half hours after the second dose had been given. At that time there was no apparent change in its condition, further than that it had become so weak that it was no longer able to stand, unless supported. It died during the following night. In the morning (13th) a patch of liquid fæces of a clay-colour was found upon the floor. Ten grammes of bile were found in the bag attached to the canula.

The result of this experiment was briefly this:—$1\frac{3}{5}$ grain corrosive sublimate, given in the course of 24 hours to a dog 6 months old, caused purgation with liquid bloody fæces, nasal discharge, diminution of the biliary secretion, general tremor, and finally death.

For dissection of this dog see Table I., Dog D. It will be observed that the stomach still contained a portion of undigested food.

As the animal had been poisoned by the drug, it was determined to observe the effects of smaller and gradually increasing doses. It was thought that if the drug can increase the biliary secretion, we, by beginning with a very small dose and gradually increasing its strength, would certainly hit upon the amount necessary to do so ere poisonous symptoms set in; moreover we should observe the effects of the repeated exhibition of small doses.

TABLE XIII.—Second Series of Observations on Dog 7. Daily amount of Bile secreted when Corrosive Sublimate was given.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			Amount of Corrosive Sublimate administered.
	Kilogs.	Water.	Milk.	Bread.	Tripe.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1868.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grms.	grm.	
June 6.	27·5	846	564	225·6	1353·6	95	4·89	0·90	3·45	0·17	0·03	17·92	0·92	0·16	One-sixth of a grain.
„ 7.	...	846	564	225·6	1353·6	101·5	5·14	*	...	...	...	...	...	...	One-sixth of a grain.
„ 8.	...	846	564	225·6	677·8	104·7	5·91	0·93	...	...	...	...	...	...	One-sixth of a grain.
„ 9.	...	846	564	225·6	916·5	143·3	4·90	1·21	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 10.	27·44	846	564	225·6	1128·0	159·6	7·32	1·41	5·82	0·26	0·05	33·6	1·54	0·297	One-sixth of a grain twice in the day.
„ 11.	...	846	564	225·6	677·8	101·8	5·83	*	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 13.	...	846	564	225·6	677·8	114·15	5·21	0·68	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 14.	...	Not accurately noted				89·0	5·39	0·80	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 15.	...	761·4	564	225·6	296·1	107·1	7·71	0·87	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 16.		846	564	225·6	916·5	115·71	7·39	1·13	...	...	...	...	...	...	One-sixth of a grain in the evening, and one-third of a grain in the morning.
Mean .	27·47	836·4	564	225·6	888·6	113·8	5·972	0·99	4·14	0·217	0·036	37·4	1·44	0·239	
June 17.	...	846	564	225·6	789·6	32·70	2·62	0·401	...	...	...	...	...	...	One-third of a grain twice in the day.
„ 18.	27·6	789	564	None.	70·5	54·60	2·93	0·40	1·97	0·10	0·014	73·6	3·01	0·56	One-third of a grain.——Total quantity, 4 grains.

* Not estimated.

NOTE.—On June 6th the dry food amounted to 530·1 grammes, or 19·27 grammes per kilog. of dog; on the 10th, 473·8 grammes, or 17·20 grammes per kilog. of dog; on the 18th, 73·9 grammes, or 2·67 grammes per kilog. of dog. Mean amount of dry food consumed daily from June 6–16 inclusive, 414·11 grammes, or 15·07 grammes per kilog. of dog.

TABLE XIV.—First Series of Observations on Dog 8. Daily amount of Bile secreted without Mercury.

June 18.	19·3	850	567	226·8	453·6	263	8·28	0·89	13·62	0·429	0·016	145	3·56	0·49	At the time of commencing observation the dog was in perfect health. Fæces quite white and semisolid.
„ 19.	...	„	„	„	„	241·6	6·76	1·40							
„ 20.	...	„	„	„	„										
„ 21.	...	„	„	„	„	200·0	5·34	1·30	...	...	...	...	...	...	Dog does not look very well. A little diarrhœa.
„ 22.	...	„	„	„	„	124·0	7·34	1·22	...	...	...	...	...	...	Diarrhœa has ceased. Dog looks well.
„ 23.	...	„	„	„	„	160·5	6·24	1·22							
„ 24.	...	„	„	„	„	158·6	5·12	0·77							
„ 25.	...	„	„	„	„	113·7	5·25	*	5·37	0·272	...	62·71	2·89		
„ 26.	19·7	676·8	846	225·6	676·8	180·3	3·40	0·70							
Mean...	19·5	763·4	706·5	226·2	565·2	180·2	5·96	1·07	9·24	0·305	0·054	51·84	1·714	0·307	

* Accidentally lost.

NOTE.—The amount of dry food consumed daily from June 18th to June 25th amounted to 181·3 grammes, or 9·3 grms. per kilog. of dog; on the 26th, 389·06 grammes, or 19·74 grms. per kilog. of dog.

Dog 7 was a strong full-grown retriever, weighing 27·4 kilogrammes, for which we were indebted to Dr. Kelburne King, of Hull. The operation for biliary fistula was performed on the 24th of April, 1868. The healing of the wound around the fistula was so slow that observations could not be begun before the 29th of May. Table XII. p. 215, gives the results previous to the administration of corrosive sublimate.

During the five days embraced by Table XII., the amount of food consumed was constant. On May 31st the bile was unfortunately lost, owing to the apparatus having slipped. The average quantity secreted during the remaining four days was of fluid bile 127·15 grammes, of bile solids 6·43 grammes, of bile salts 1·03 gramme. The observations were interrupted on account of repairs needed in the apparatus. When resumed on the 5th of June, the dog was in excellent health. Table XIII. p. 217, gives the results of observations during the administration of small and gradually increasing doses of corrosive sublimate.

During the first three days $\frac{1}{6}$ of a grain of corrosive sublimate was injected under the skin once a day. During the next six days the same quantity was injected twice a day, and on the tenth day (June 16) the dose was increased to $\frac{1}{3}$ of a grain at the second injection.

During these ten days the biliary secretion underwent marked variations; the average daily quantity was 113·8 grammes of fluid bile, 5·972 grammes of bile solids, and 0·99 gramme of bile salts. These figures show that there was a slight diminution in the biliary secretion during this period. At the same time, however, the amount of food consumed had undergone a considerable decrease, but the health of the animal had not suffered, and its weight remained almost exactly the same. On June 17, the increased dose of $\frac{1}{3}$ of a grain *twice* a day was given. Athough these doses produced no purgation, fœtid breath, or salivation, yet the dull eye and general drooping uneasy aspect of the animal showed that the general health was decidedly impaired. On that day (17th) there was a great decrease in the biliary secretion. The bile solids fell to about a third, and the fluid bile to about a fourth of what it had been on the previous day. The amount of food consumed, however, had been but slightly diminished, as compared with the previous day; but a glance at the Table will suffice to show that more food was consumed on the 17th than on the 11th, 13th, and 15th. On all these days at least thrice as much fluid bile, and about twice as much bile solids had been secreted. On June 18 only $\frac{1}{3}$ of a grain was given; and after the collection of bile on that day the observations were suspended, on account of the very marked impairment of the general health occasioned by the mercury. On that day the following is the note that was taken of the condition of the animal:—"The dog looks miserable and lifeless, his health is evidently much impaired, there is no salivation, fœtid breath, nasal discharge, or purgation." The quantity of bile secreted on the 18th, though above that of the previous day, was nevertheless very low. The consumption of food had greatly diminished; and it should be noticed that on the 10th the biliary secretion, instead of undergoing a still further diminution, consequent on the decreased consumption of food, was, in fact, augmented. This, in our opinion, could only be attributed to the influence of a smaller dose of the drug.

The collection of the bile was in this case quite perfect on every day, with one exception (May 31), recorded in Table XII. The observations distinctly show that corrosive sublimate, given in small gradually increasing doses, did not augment the biliary secretion. On the contrary, they point out

TABLE XV.—Second Series of Observations on Dog 8. Daily amount of Bile secreted when Corrosive Sublimate was given.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			Amount of Corrosive Sublimate given.
	Kilogs.	Water.	Milk.	Bread.	Tripe.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1863.						grms.	grms.	grm.	grms.	grm.	grm.	grms.	grm.	grm.	
June 27.	19·70	676·8	846	225·6	676·8	172·2	4·30	1·60	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 28.	„	676·8	846	225·6	676·8	137·0	3·20	1·10	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 29.	„	676·8	846	225·6	676·8	142·8	3·55	1·02	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 30.	„	846·0	846·0	225·6	676·8	162·7	4·23	1·31	...	...	...	...	...	...	One-sixth of a grain twice in the day.
July 1.	„	846·0	846·0	225·6	None.	113·3	2·09	0·69	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 2.	19·82	1071	846·0	225·6	451·2	179·47	4·77	0·879	9·06	0·24	0·044	53·9	1·43	0·264	One-sixth of a grain twice in the day.
„ 3.	„	1241	846	225·6	366·6	147·1	3·30	1·381	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 4.	„	1241	846	225·6	141·0	145·0	2·68	1·19	...	...	...	...	...	...	One-sixth of a grain twice in the day.
„ 5.	„	1241	338·4	51·6	239·7	145·0	2·68	1·19	...	...	...	...	...	...	One-sixth of a grain in the evening, one-third in the morning.
„ 6.	19·59	1241	846·0	225·6	239·7	157·2	2·11	0·48	8·02	0·107	0·024	56·19	0·75	0·171	One-sixth of a grain in the evening, one-third in the morning.
„ 7.	...	1241	846·0	225·6	423	153·0	3·67	1·346	...	...	...	...	...	...	One-third of a grain twice in the day.
„ 8.	...	1241	308·9	183·3	56·4	147·51	4·115	1·44	...	...	...	...	...	...	One-third of a grain twice in the day.
Mean...	19·7	1019	754·4	207·8	420·4	150·19	3·374	1·135	7·62	0·171	0·057	49·2	1·105	0·372	
July 9.	...	1241	126·9	42·3	None.	74·2	2·04	0·570	...	...	...	...	...	...	One-third of a grain twice in the day.
„ 10.	16·10	Taken	a littl	e milk.	42·3	17·5	0·133	0·05	1·086	0·008	0·003	...	...	...	One-third of a grain.——Total quantity, six grains.

NOTE.—On July 2nd the dry food consumed amounted to 332·76 grammes, or 16·70 grammes per kilogramme of dog; on the 6th, 279·8 grammes, or 14·2 grms. per kilog. of dog; on the 10th, salivation and ulceration of gums appeared; on the 1st the tripe was stinking when given.

TABLE XVI.—Third Series of Observations on Dog 7. Daily amount of Bile secreted before, during, and after partial starvation.

July 26.	29·5	311·7	226·7	141·7	1813	140·8	5·04	0·88	4·7	0·170	0·029	2·15	0·89	0·15	Dog in excellent health.
„ 27.	„	850·2	„	„	1728·7	139·9	5·14	1·00	...	...	...	...	...	...	Dog in excellent health.
„ 28.	„	None.	None	None.	Liver. 453·4	101·8	7·73	1·03	...	...	...	100·5	7·4	0·98	Dog in excellent health.
„ 29.	28·6	453·4	„	„	None.	41·6	2·77	0·40	1·45	0·096	0·013	...	...	...	Dog in excellent health.
„ 30.	...	850·2	226·7	141·7	None.	85·7	5·11	0·87	...	...	...	79·57	4·74	0·808	Dog in excellent health.
„ 31.	28·6	425·0	„	„	Tripe. 1813·7	173·9	9·35	1·68	6·08	0·326	0·058	31·0	1·66	0·29	Dog in excellent health.

NOTE.—On July 26 the dry food amounted to 560·9 grammes, or 19·01 grammes per kilogramme of dog; on the 28th the dry food amounted to 104·2 grammes, or 3·64 grammes per kilogramme of dog; on the 29th no dry food was given; on July 30th the dry food amounted to 107·7 grammes, or 3·7 grammes per kilogramme of dog; on the 31st the dry food amounted to 560·9 grammes, or 19·9 grammes per kilogramme of dog.

that so long as the general health remained good, the amount of bile was not changed, but as soon as the animal became weak, diminution of the secretion at once took place.

Dog 8 was a strong mongrel collie, about five years old, weighing 19·3 kilogrammes. The operation for biliary fistula was performed on the 2nd of June, 1868. The recovery was rapid, and observations, with a view to determine the normal secretion of bile, were commenced June 17th. The results are given in Table XIV. p. 217.

The bile was perfectly collected for eight days. On one day (20th) the apparatus was not applied. When the observations were commenced, the animal was in perfect health, the fæces were quite white and semisolid. On the 21st it had a slight attack of diarrhœa, which had, however, disappeared on the following day. With this exception, the health of the animal was exceedingly good during the whole period, and instead of a loss there was a slight gain in weight. The diminution of the biliary secretion on the 21st cannot be ascribed to the diarrhœa, seeing that on the next day, when it had ceased, a still greater decrease took place. The average daily amount of bile during the above period was, of fluid bile 180·2 grammes, of bile solids 5·96 grammes, of bile salts 1·07 gramme. The dog's appetite was remarkably good. It was decided that corrosive sublimate should now be given in small and gradually increasing doses as in the previous case. Table XV. p. 219, gives the results.

During the first eight days $\frac{1}{6}$ of a grain of corrosive sublimate was given twice a day. On July 5th and 6th $\frac{3}{6}$ of a grain were given in the day. On July 7th and 8th the dose was $\frac{1}{3}$ of a grain twice a day. Until July 8th the animal continued in good health; then its appetite began to fail.

The average amount of bile secreted daily during the twelve days from June 27th to July 8th inclusive was, of fluid bile 150·19 grammes, of bile solids 3·374 grammes, and of bile salts 1·135 gramme. During this period the amount of fluid bile was one-sixth less than during the premercurial period; but the diminution in the bile solids was still more marked, the average quantity not being much more than a half of what was secreted during the premercurial period. This diminution was entirely due to a decrease in the organic solids of the bile, indeed the amount of the *inorganic* solids was slightly increased.

On July 9th two-thirds of a grain were given, as on the two previous days. The falling off in the appetite now became more marked, and the animal looked ill. There was a great failure in the biliary secretion; fluid and solid bile were reduced to about a half of what they had been on the previous day. One-third of a grain was given upon the following day (10th). This was the last dose. Symptoms of seriously deteriorated health were very apparent some hours after it was given. The animal refused almost all food; it looked very languid; its breath was fœtid; there was slight salivation, and on the mucous membrane inside the upper lip there was an incipient ulcer, which experience regarding the effects of mercurials on the mouths of other dogs enabled us to recognize as mercurial. The fæces, which previous to the administration of the mercury had been white, were during the greater period of exhibition sometimes white, at other times grey, and during the two last days of a slate-colour. There never was purgation. Latterly the animal became rapidly emaciated. Up to the 6th it maintained its weight well, but during the last four days it lost 3·49 kilo-

grammes. The amount of bile secreted on the 10th was still further diminished, the fluid bile being little more than a ninth of the average quantity secreted during the twelve days from June 27th to July 8th inclusive; while the bile solids were little more than a thirtieth of the average quantity secreted during the same period.

In the case of dog 8 six grains, in that of dog 7 four grains of corrosive sublimate were required to bring about the same result as regards the biliary secretion. This was apparently due to the fact that dog 8 was an older and a stronger dog. But although the biliary secretion held out longer against the drug in this animal, the constitutional symptoms were more marked. Thus salivation, fœtid breath, and ulceration of the gums were present, while these were wanting in dog 7. This fact adds greatly to the value of the observations on dog 8; for it shows when mercury is given to an extent sufficient to increase the function of the salivary glands, it diminishes the biliary function of the liver.

The impression produced by the drug upon the health of dog 8 was deep and lasting. Although its administration and the collection of bile were stopped on July 10th, the emaciation of the animal continued to increase rapidly. The appetite was very poor on the 14th, there was coffee-ground vomiting, blood was passed in the fæces, and there was a decided mucopurulent discharge from the left nostril. The ulcer in the mouth became larger. The animal, which previous to the administration of the mercury had been so strong and vigorous, grew so weak that it could hardly walk, and it was killed July 25th. On dissection six hours after death nothing abnormal was found. The hepatic cells seemed healthy. The intestine, pancreas, and salivary glands were not unduly vascular.

Results of the preceding Observations on the Cholagogue Action of Corrosive Sublimate.

These two series of observations on dogs 7 and 8 so closely resembled each other, and were so perfectly carried out, that there was no possibility of fallacy. They show:—

1. That corrosive sublimate, when given in small doses, gradually increased in strength, does not augment the biliary secretion, but that it diminishes it the moment the dose reaches a strength sufficient to deteriorate the general health.

2. That corrosive sublimate given in the above method may diminish the biliary secretion, while it does or does not produce an evident action on the salivary glands and mouth, and without producing purgation.

3. Case 6 shows that the biliary secretion is likewise diminished when this drug is given in a dose sufficient to produce purgation.

The next subject which engaged our attention was the mode in which the mercury had caused a diminution of the biliary secretion in dogs 7 and 8.

The experiment on dog 8 seemed strongly to point to the diminished consumption of food as the cause of the diminished biliary secretion. With a view to throw further light on this matter, we performed the following experiment on the

Influence of Partial Starvation on the Biliary Secretion.

For the following experiment dog 7 was used, which had thoroughly recovered its health and strength.

Table XVI., p. 219, shows the results of the observations before, during, and after partial starvation.

During the first two days the amount of bile fluid and solids secreted was very nearly the same. The amount of dry food consumed was also nearly alike.

On the 28th, bread, milk, and water were withheld. It was intended to give the usual allowance of tripe, but as it could not be obtained, liver was given instead. On this day the amount of fluid bile fell to 104·8 grammes, as compared with 140 grammes on the two previous days, but the bile solids rose to about a half more than they had previously been. This was almost wholly due to increase of the organic constituents of the bile; for it will be seen from the Table that the bile salts (inorganic solids) were scarcely at all increased. July 29th 453 grammes of water were given without any dry food.

The quantity of fluid bile secreted was only 41·6 grammes, less than a third of the quantity on the days previous to starvation. The amount of bile solids was 2·77 grammes, rather more than a half of the quantity secreted during the first period, while the inorganic constituent of the bile fell to 0·40 gramme, less than a half of the amount during the first period. On the 30th of July it was intended that the animal should return to the diet of July 27th, but the tripe was accidentally withheld. The amount of fluid bile rose on that day to 85·7 grammes, bile solids to 5·11 grammes, and bile salts to 0·87 gramme. Although the dry food consumed on this day was hardly one-fifth of what it was on July 26th, the amount of bile solids and salts was almost the same. On July 31st the partial starvation was discontinued; the animal consumed the same amount of dry food as on July 26th, with nearly a fourth more water. The fluid bile on that day reached a quantity 33·1 grammes above what it was on the 26th, when the same quantity of food was given, while the amount of bile solids and salts was nearly doubled. It is difficult to account for this marked increase in the biliary secretion when the full diet was again given. During the whole experiment the animal was in excellent health, and lost only 0·9 kilogramme in weight.

The preceding observations are sufficient to show that the biliary secretion is greatly influenced by the great amount of food consumed, and it permits of the inference that diminution in the biliary secretion observed in the case of dog 8 under the influence of corrosive sublimate may have been due to impaired appetite. The same explanation cannot apply to the diminution in the biliary secretion observed in the case of dog 7 on June 17 (see Table XIII.); for, as has been previously pointed out, on that day the animal took more food than it had done on many previous days on which it had secreted a larger amount of bile.

On the whole, therefore, the legitimate conclusion seems to be that mercury, when administered so as to impair the general nutrition, lessens the biliary secretion. This may result without impairment of the appetite; but when there is a diminished consumption of food, the failure in the biliary secretion is all the more marked.

Conclusions regarding the Cholagogue Action of Mercury.

The foregoing observations seem to us clearly to show that Pil. Hydrargyri, calomel, and corrosive sublimate, when given to dogs in either small, gradually augmented, or in large doses, do not increase the biliary secretion; they do not even influence it so long as neither purgation nor impairment of health are produced, but they diminish it as soon as they do either or both. It may be

urged that, although we have proved this regarding dogs, it does not follow that on man these drugs will have the same action. It must be admitted that some animals are altogether insensible to remedies which produce powerful effects on others, that different doses are often requisite to occasion similar results, and that there may be peculiarities so very decided as to render it impossible to infer what will be the action of a remedy on one animal from its influence upon another. But have we any reason to conclude that in the present instance there exists such difference in the action of mercury as to prevent any inference being drawn from the dog regarding man? All the facts with which we are acquainted show that it is legitimate to infer that the action of mercury ought to be regarded as similar in both cases. We have demonstrated that, as regards its action upon the salivary glands, mouth, intestine, appetite, and general nutrition, the influence of mercury is the same. We therefore infer that it is in the highest degree probable that its action on the hepatic secretion will also be the same. The only difference that there seems to be between the dog and man, as regards the action of mercury, consists in the fact that in the dog larger doses are generally required to produce the same effects as those observed in man. But even here it may be argued that more marked results are required to satisfy the observer, and hence the greater dose necessary. These circumstances, therefore, cannot be held as affecting the conclusion at which we have arrived.

We have not deemed it worth our while to experiment upon any other animal, for we are unable to see how such experiments could materially strengthen our position. Even though we had shown that mercury when given to a rabbit, cat, pig, donkey, or horse diminishes the biliary secretion, it might still be said that this does not apply to man. But there are several special reasons which render experiments on these animals either impracticable or less reliable than those on the dog. Bidder and Schmidt failed to establish biliary fistulæ in cats, we therefore thought it not worth our while to spend money and time in making the attempt. Horses and donkeys are too unwieldy for the purpose and have no gall-bladders, a peculiarity which would in all probability render it impossible to establish biliary fistulæ in them. In pigs the hepatic secretion differs from that of man, inasmuch as it contains hyocholic acid, and according to Strecker no sulphur. It might, therefore, not unfairly be objected to any inferences from experiments on pigs that, inasmuch as the porcine differs from the human hepatic secretion, it could not be held as altogether probable that mercury would influence both in the same way. Everything seems to show that the animals used by the Committee are those best suited for the observations they have made. In addition to the therapeutical facts previously mentioned, which after all are the most important, there are these, that the qualitative composition of canine is the same as that of human bile, and that the dog, like man, can be fed on a flesh, vegetable, or mixed diet. In this respect they are superior to most others, even to the Quadrumana, which though in conformation most resembling man are vegetable feeders. So far, therefore, as direct experiment and exact observations are capable of determining the influence of mercury upon the biliary secretion, the Committee have no doubt that the dog is superior to the animals above mentioned.

But it may be supposed that mercurials possess some specific power of exciting the biliary secretion by acting on the orifice of the common bile-duct, and so stimulating the secretion through the nerves which connect it with the liver, just as pyrethrum or vinegar stimulates the salivary glands when they are applied to the orifices of the salivary ducts. It might also be objected that,

inasmuch as in our experiments the common bile-duct had been divided, the nerves alluded to might have been so injured that stimulation of the orifice of the common bile-duct could no longer excite the secretion. It remains to be shown, however, that mercurials do specially excite the orifice of the bile-duct. It is not probable, at any rate, that their influence on the biliary secretion was, in the cases of dogs 6, 7, and 8, prevented by division of hepatic nerves. In these experiments the common bile-duct was simply divided with as little injury to neighbouring parts as possible (in previous experiments a portion of the bile-duct was removed), and these animals did not suffer in the least from the shock after the operation; so that nervous injury could not have been extensive. Moreover, in the case of dog 7, the parts around the common bile-duct were dissected after death, and the nerves proceeding from the solar plexus to the liver were found at some distance from the duct, and had apparently suffered no injury at the place where it had been divided. The Committee, therefore, do not attach any value to this objection.

But some may say that although we have proved that mercury diminishes the biliary secretion in dogs and that in man its action will in all probability be the same, yet our experiments have been performed on animals in a state of health, and that had they been made on dogs with diseases such as those in which mercury has been *supposed* to increase the hepatic secretion, it would possibly, in the case of such dogs, have been increased. With such an hypothesis we need not seriously occupy ourselves until the objectors *prove* that, in any case whatever, mercury can increase the biliary secretion in man.

We have been unable to discover any facts brought to light in this or any other age which prove that mercury stimulates the biliary secretion. So far as we can make out, the notion that it does so originates in some vague statement made by Paracelsus*, or the authors of his time, as to the good effects of mercury in what he has called "icteritia." But, we repeat, not only do we not know how such a notion has arisen, but we are ignorant how to make direct observations on the subject in man. We have already stated that such observations are, in the present state of physiological chemistry, impossible (see p. 187). We do not deny the possibility of mercury being useful in some diseases of the liver; we simply say that the notion of its doing good by increasing the biliary secretion is untenable.

Observations on Podophylline and Taraxacum as Cholagogues.

Before concluding our observations on dogs with biliary fistulæ, the Committee thought it would be important to try the effect of two other drugs which have been supposed to exercise a cholagogue influence on the liver, viz. podophylline and taraxacum.

Observations with Podophylline.

Dog 9 was a retriever, about three years old, weighing 26·6 kilogrammes, and the operation for biliary fistulæ was performed upon July 24, 1868. The recovery was rapid. Shortly after the operation the fæces were clay-coloured. Table XVII., p. 225, shows the results of the bile collections previous to, during, and after the administration of podophylline.

* Paracelsus (Aur. Phil. Theoph.), Opera Medico-Chemica, 3 tom. 4to, Francof. 1603-1605. De Icteritiis, vol. i. p. 329.

TABLE XVII.—Observations on Dog 9. Daily amount of Bile secreted before and after the administration of Podophylline.

1	2	3				4			5			6			7
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			For each kilogramme of dog there were secreted			For each 100 grammes of dry food there were secreted			Observations.
	Kilogs.	Water.	Milk.	Bread.	Liver.	Fluid bile.	Bile solids.	Bile. salts.	Fluid bile.	Bile solids.	Bile salts.	Fluid bile.	Bile solids.	Bile salts.	
1868.						grms.	grms.	grms.	grms.	grm.	grm.	grms.	grms.	grm.	
Aug. 7.	26·6	564	346·6	141·0	676·8	273·0	15·47	1·91	10·2	0·53	0·07	99·3	5·6	0·69	Dog in excellent health. No medicine given.
„ 8.	...	„	141·0	84·6	846·0	285·8	14·54	2·47	...	...	...	...	...	...	Dog in excellent health. No medicine given.
„ 9.	...	„	282·0	112·8	561·0*	301·2	12·98	2·22	...	...	...	...	...	...	2 grains Resina Podophylli given 24 hours previous to this collection. *Bowels not moved.*
„ 10.	26·4	„	84·6	56·4	„	287·0	13·31	2·75	...	...	...	...	...	...	Bowels moved once. Fæces solid.
„ 11.	25·7	„	None	None.	902·4†	203·2	10·85	1·95	7·9	0·42	0·07	97·9	5·2	0·93	4 grains given 24 hours previous to this collection. *Decided purgation.*
„ 12.	...	„	225·6	141·0	None.	238·2	6·62	1·65	...	...	...	...	...	...	Bowels not moved.
„ 13.	24·5	„	„	„	338·4†	151·2	4·00	0·98	6·1	0·16	0·04	82·0	2·1	0·53	6 grains podophylline given 24 hours previous to this collection. *Decided purgation.*
„ 14. „ 18.	...	„	„	„	676·8	238·4	12·87	1·95	...	...	...	...	...	...	Dog in good health.

* The collection which followed the administration of the purgative when it did not produce purgation. † Those which followed purgation.

NOTE.—Amount of dry food consumed on August 7, 274·8 grammes, or 10·3 grms. per kilog. of dog; on the 11th, 207·5, or 8·0 grms. per kilog. of dog; on the 13th, 184·0 grammes, or 7·5 grms. per kilog. of dog.

TABLE XVIII.—Fourth Series of Observations on Dog 7. Daily amount of Bile secreted before and after Podophylline was given.

Aug. 7.	28·6	507·6	225·6	141·0	1325·4	246·95	13·91	2·09	..	..	..	..	..	..	Dog in excellent health.
„ 8.	„	„	„	„	1579·2	148·3	9·33	1·40	5·1	0·32	0·04	30·3	1·9	0·29	Has had a smart attack of dysentery; 5 grains Pulv. Doveri removed it.
„ 9.	28·4	451·2	„	„	„	210·5	13·78	1·97							
„ 10.	..	310·2	„	„	„	249·5	12·64	2·04							
„ 11.	..	..	„	..	..	..	..	..	..	..	..	..	..	..	Canula could not be introduced owing to false passages.
„ 12.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Canula could not be introduced owing to false passages.
„ 13.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Canula could not be introduced owing to false passages.
„ 14.	28·7	846·0	„	„	„	256·8	12·48	2·01	8·9	0·43	0·07	52·6	2·5	0·41	
„ 15.	28·4	„	„	„	None.	156·1	9·88	1·41	5·4	0·34	0·04	180·0	11·3	1·6	8 grains podophylline given 24 hours previous to this collection. *Profuse purgation.* Dog looking very ill. Staggers when it walks.

NOTE.—The amount of dry food on August 8th was 486 grammes, or 16·9 grms. per kilog. of dog; on the 14th, 486 grammes, or 16·9 grms. per kilog. of dog; on the 15th, 86·8 grammes, or 3·0 grms. per kilog. of dog.

On August 7th and 8th the bile was collected to ascertain the normal secretion previous to the exhibition of the drug. On the ninth day 2 grains of Resina Podophylli (prepared by Messrs. Gardner and Ainslie, druggists, Edinburgh) were given. This amount did not produce purgation. The bile was collected 24 hours after the dose was given, and it was found that the fluid bile had risen from 285·8 to 304·2 grammes, but the solid bile had fallen from 14·5 to 12·9 grammes. On the 10th no medicine was given. On that day the fluid bile fell somewhat, while the solid bile rose. On the 11th 4 grains of podophylline were given. Decided purgation followed. A marked diminution in the fluid and solid bile was the result—the fluid bile fell from 287 to 203·2 grammes, the bile solids from 13·31 to 10·85 grammes. On the 12th no medicine was given: the fluid bile rose to 238·2 grammes, while, strange to say, the bile solids fell to 6·62 grammes. On the 13th 6 grains of podophylline were given. Decided purgation followed. The fluid bile fell to 151·2, the bile solids to 4 grammes. On the 14th no medicine was given, and, notwithstanding the purgation, the dog was in excellent health. On the 14th the fluid bile rose to 238·4, the bile solids to 12·87 grammes.

These observations clearly show that in this case podophylline, when it produced purgation, diminished the biliary secretion. This decrease cannot be accounted for by diminution in the amount of food taken. Certainly such an explanation might be advanced to account for the fall in the quantity secreted on the 11th, but it cannot possibly apply to the great fall upon the 13th.

Little attention need be paid to the increase in the bile fluid on the 9th, when 2 grains of podophylline were given without purgation resulting; for it was only 18·4 grammes, whereas on the 8th there had been a rise of 12·8 grammes over the quantity on the previous day, without any drug having been given; moreover, on the 9th the bile solids fell to a decided extent.

The observations recorded in Table XVIII. p. 225, were made on dog 7, after he had regained his health.

The bile was collected for five days previous to the exhibition of podophylline. On one of these (August 8) the dog had a smart attack of dysentery; on that day the solid and fluid bile was much below what it was on any other day of the period—another evidence of the lowering influence of purgation upon the biliary secretion.

On August 15th 8 grains of podophylline were given; it produced profuse purgation, and so weakened the animal that it staggered when it walked. The bile was collected 24 hours after the dose was given; both fluid and solid bile had undergone a great diminution. It is curious to observe that the purgation produced by the podophylline, although it was accompanied by a diminished consumption of food, did not lessen either the fluid or solid portions of the bile to the extent effected by the attack of dysentery, although the latter was accompanied by comparatively slight depression of the general health and appetite. Throughout the observations in Table XVIII. the fæces were of a slate-colour.

The observations were discontinued owing to the weakness of the animal. The observations recorded in Table XIX. p. 227, were made on dog 5 after it had regained its health.

The bile was collected for two days, August 23rd and 24th, to ascertain the normal secretion. On August 25th and 26th 6 grains of Resina Podophylli were given; both doses occasioned decided purgation. The effect on the biliary secretion was unequivocal. On the day preceding that on which

the first dose was given the fluid bile was 220·9 grammes, bile solids 10·42 grammes; on the following day the fluid bile was 154·5 grammes. After the second dose the fluid bile was 150 grammes, the bile solids 1·95 gramme. The next day (27th) no medicine was given, and the fluid bile rose to 297 grammes, and the bile solids to 11·99 grammes, most conclusively showing that doses of podophylline which produce purgation diminish the fluid and solid constituents of the bile.

TABLE XIX.—Second Series of Observations on Dog 5. Daily amount of Bile secreted before, during, and after Podophylline and Taraxacum were given.

1	2	3				4			5
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			Observations.
	Kilogs.	Water.	Milk.	Bread.	Spleen.	Fluid bile.	Bile solids.	Bile salts.	
1868.						grms.	grms.	grms.	
Aug. 23.	14·7	566	566	225·6	906·8	282·8	11·56	3·0	Dog in good health, though rather lean. Fæces semisolid.
„ 24.	..	„	„	„	„	220·9	10·42	2·84	Dog in good health, though rather lean. Fæces semisolid.
„ 25.	..	„	„	„	„	154·5	4·20	1·58	6 grains Resina Podophylli given 20 hours previous to the collection of bile. *Profuse purgation.*
„ 26.	14·6	„	„	„	„	150	1·95	0·52	6 grains Resina Podophylli given 23 hours previous to this collection of bile. *Decided purgation.*
„ 27.	..	„	„	„	„	297	11·99	3·21	No medicine given.
„ 28.	..	„	„	„	842·1	396	10·21	2·42	60 grains solid extract of taraxacum given 24 hours before this collection of bile. *No purgation.*
„ 29.	14	„	„	„	906·8	340	9·36	2·12	60 grains solid extract of taraxacum given 24 hours before this collection of bile. *No purgation.*
„ 30.	..	„	„	„	„	Lost.	..	..	No medicine given.
„ 31.	..	„	„	„	„	Lost.	..	..	No medicine given.
Sept. 1.	..	„	„	„	„	317	9·42	2·46	No medicine given.
„ 2.	..	„	„	„	„	355·5	10·61	3·02	No medicine given.
„ 3.	14·3	„	„	„	„	298	9·53	2·27	No medicine given.

NOTE.—As the weight of the dog and the amount of food eaten by it were so constant in this case, we have not thought it necessary to calculate the amount of bile secreted per kilogramme weight of dog, or per 100 grammes of food consumed.

Observations with Extract of Taraxacum.

After dog 5 had had a day's rest from the action of podophylline, 60 grains of solid extract of taraxacum were given 24 hours previous to the collection of bile on August 28th; on that day the fluid bile rose to the extent of 99 grammes, but the bile solids fell to the extent of 1·78 gramme. Next day the same dose was repeated; the fluid bile fell to the extent of 56 grammes, the bile solids to the extent of 0·85 gramme. Neither dose produced any effect upon the bowels. After this no more medicine was given. The bile was unfortunately lost on August 30th and 31st, owing to slipping of the apparatus; on the three following days the amount of fluid bile fluctuated greatly. On September 2nd it was 355·5 grammes,—a larger quantity than that secreted during the 24 hours after the second dose of the taraxacum was given; on that day also (September 2nd) the amount of bile solids secreted was greater than on either of the days on which taraxacum was given. It is therefore evident that the taraxacum did not increase the solid constituents of the bile; and it is extremely probable that the large amount of fluid bile secreted after the first dose was

due to other causes. On September 2nd, when no taraxacum was given, the bile rose to the extent of 38·5 grammes over the amount on the previous day, and on September 3rd it fell to the extent of 57·5 grammes without any assignable cause. On the whole, therefore, it seems that taraxacum exercised no influence upon the biliary secretion. On September 3rd the observations were discontinued, as the margins of the fistula had become much ulcerated.

Taraxacum was also given to dog 7, which had been the subject of the observations recorded in Tables XII., XIII., XVI., and XVIII., which had recovered his health.

Table XX.—Fifth Series of Observations on Dog 7. Daily amount of Bile secreted before and during the administration of Extract of Taraxacum.

1	2	3				4			5
Date.	Weight of dog.	Amount of food, in grammes.				Quantity of bile secreted in 24 hours.			Observations.
	Kilogs.	Water.	Milk.	Bread.	Tripe.	Fluid bile.	Bile solids.	Bile salts.	
1868.						grms.	grms.	grms.	
Aug. 26.	29·4	846	564	225·6	1353·6	192	8·53	2·10	Dog in excellent health. Fæces solid.
„ 27.	..	„	„	„	„	176	10·52	2·36	Dog in excellent health. Fæces solid.
„ 28.	29·5	„	„	„	„	214	8·93	1·94	60 grains solid extract of taraxacum given twenty-four hours before this collection of bile. *No purgation.*
„ 29.	..	„	„	„	„	188	9·64	2·12	120 grains solid extract of taraxacum given twenty-fours before this collection of bile.
„ 30.	..	„	„	„	„	151	9·99	2·45	
„ 31.	29·3	„	„	„	None.	140	8·43	1·64	
Sept. 2.	..	652	„	„	1353·6	212·2	12·9	3·76	No medicine given. Dog in excellent health.
„ 3.	29·2	846	„	„	„	168	8·04	2·51	
„ 8.	31·2	„	„	„	„	251·1	12·17	3·21	
„ 9.	..	„	„	„	„	169·4	8·61	2·61	
„ 10.	..	„	„	„	„	180·6	8·84	1·98	120 grains solid extract of taraxacum given twenty-four hours before this collection of bile. *No purgation.*
„ 11.	31	„	„	„	„	159	9·12	2·31	240 grains solid extract of taraxacum given twenty-four hours before this collection of bile. *No purgation.* Dog in excellent health.

After the bile had been collected for two days 60 grains of solid extract of taraxacum were given; twenty-four hours afterwards (August 28) the fluid bile rose to the extent of 38 grammes, while the bile solids fell to the extent of 1·59 gramme. Next day (29) 120 grains were given, and the fluid bile fell to the extent of 26 grammes, while the bile solids rose to the extent of 0·71 gramme as compared with the previous day. These doses had no effect upon the bowels. After this, the bile was collected for five consecutive days, on which no medicine was given; on one of these days (September 1) the bile was lost owing to slipping of the apparatus. On September 2 the fluid bile reached a figure very nearly as high as it had attained during the administration of taraxacum, and the bile solids were higher than they had ever been on any of the previous days. On September 4 the apparatus was left off owing to ulceration of the skin; on September 7 it was reapplied, and the bile was collected on the four subsequent days. The large quantities obtained (September 8) the first of these days need not be paid attention to; it was most probably due to escape of bile pent up in the bile-ducts, owing to the canula not having been used during the previous four days. Twenty-four hours previous to the collection on the 10th, 120 grammes of solid extract of taraxacum were given; on that day the fluid bile rose to

the extent of 11·2 grammes, and the bile solids to the extent of 0·23 gramme. Next day 240 grains were given, and the fluid bile fell to the extent of 21·6 grammes, while the bile solids rose to the extent of 0·38 gramme. These doses produced no effect upon the bowels. The fæces were always solid. The dog was in most excellent health when these observations were discontinued.

The observations recorded in Table XX. show, even more conclusively than those recorded in Table XIX., that taraxacum did not influence the biliary secretion in any way whatever.

Results of the Observations recorded in Tables XVII., XVIII., XIX., *and* XX.

1. Doses of podophylline, varying from 2 to 8 grains, when given to dogs diminished the solid constituents of the bile, whether they produced purgation or not.

2. Doses which produced purgation lessened both the fluid and solid constituents.

3. During an attack of dysentery both the fluid and solid constituents of the bile were greatly lowered.

4. Doses of the solid extract of taraxacum, varying from 60 to 240 grains, affected neither the biliary secretion, the bowels, nor the general health of the animal.

Influence of Purgation upon the Biliary Secretion.

The observations of the Committee conclusively show that purgation produced by a variety of causes diminished both the fluid and solid constituents of the biliary secretion. Spontaneous diarrhœa (Table X.), dysentery, (Table XVIII.), and purgation produced by Pil. Hydrargyri (Table X., and non-tabulated observations on dog 7, see p. 214), by calomel (Table X.), by corrosive sublimate (Table XI.), and by podophylline (Tables XVII., XVIII., and XIX.) always diminished the solid constituents of the bile, and with one exception (see July 29, Table X.) the fluid portion of the bile also. That purgation diminishes the biliary function of the liver is one of the most important facts established by the Committee. It is, however, nothing more than what might have been expected, seeing that purgation drains the portal blood from which the bile is almost entirely formed.

Relation of Biliary Secretion to Consumption of Food.

The observations of the Committee show that the relation between the biliary secretion and the amount of food consumed is by no means such a close one as Bidder, Schmidt, Arnold, and others have supposed. On looking at the collections of bile in the healthy animal previous to the administration of drugs, it will frequently be seen that while eating the same food, and without there being any apparent disturbing cause, such as diarrhœa, &c., the amount of bile was nearly a half (Tables II. and III.) and even four-fifths less (Table VIII.) than on previous and subsequent days. Further, it was frequently observed that although the amount of food consumed varied greatly the secretion of bile was remarkably constant. In Table XI. are observations which illustrate this fact. During three days of perfect health the animal secreted very nearly a constant amount of bile fluid and bile solids, although the amount of food varied greatly. Thus on the first day it took 73·7 grammes of dry food, on the second day it took 14·16, and on the third day 62·37 grammes; on these days the amount of bile secreted per

100 grammes of dry food was on the first day 5·64 grammes, on the second day 30·4 grammes, and on the third day 6·9 grammes. The observations recorded in Table XVI. show, however, that the biliary secretion was in the case of dog 7 greatly influenced by the amount of dry food; it will there be seen that the amount of bile secreted was greatly diminished by starvation. It therefore appears that the biliary secretion is in some cases greatly influenced by the amount of food taken, while in other cases it is not influenced at all.

Relation between Biliary Secretion and Weight of Animal.

The close relation supposed to exist between the amount of the biliary secretion and the size or weight of the animal has not been supported by the observations of the Committee. The amount of bile secreted for every kilogramme weight of dog varied greatly in different cases, as the following Table shows.

Table XXI.—Average amount of Bile secreted per Kilogramme Weight of the Dogs observed by the Committee before drugs were administered.

No. of dog.	Fluid bile.	Bile solids.
	grms.	grm.
Dog 1.........	6·47	0·412
„ 1.........	7·82	0·28
„ 2.........	5·27	0·34
„ 3.........	5·76	0·293
„ 4.........	3·53	0·146
„ 5.........	21·8	0·801
„ 6.........	20·66	0·818
„ 7.........	4·64	0·23
„ 8.........	9·24	0·305
„ 9.........	10·2	0·58

The foregoing Table gives the per kilogramme biliary secretion only when the dogs were healthy, and not subjected to the action of drugs. The Table shows how fallacious are the calculations which have been made regarding the human biliary secretion, from observations upon dogs, by Bidder and Schmidt. We at one time thought that the large secretion in the case of dog 5 might be due to the fact that it ate liver instead of muscle like the other dog 9; it secreted nearly as much bile, however, when, instead of liver, it ate spleen. Moreover, such an explanation could not be offered in the case of dog 6, which secreted nearly as much bile per kilogramme as dog 5. This dog was fed on a diet the same as that given to dogs 1, 2, 3, and 4, so that no peculiarity in the nature of the diet can be alleged as the cause of the large secretion in the case of dog 6. Nor can the quantity of food it took have been the cause; for the animal secreted more bile per 100 grammes of dry food than any other dog under the observation of the Committee. Seeing, then, that in the case of dog 6 neither the food nor the size of the animal can at all account for the amount of bile secreted, we must look for the cause elsewhere. One member of the Committee suggested that perhaps the amount of bile secreted may have a closer relation to the size of the liver than to the size of the animal. Unfortunately this idea did not occur until after dog 6 was killed, so that its liver was not weighed; but there is this much to be said, that dog 6 was a young dog (six months' old); and we know that in young animals the liver is larger in pro-

portion to the rest of the body than it is in more advanced age. To ascertain whether or not there be anything in this idea would require observations to be made on dogs of various sizes and ages. The biliary secretion, amount and nature of food, and weight of the animal would require to be observed for three or four days; the animal ought then to be immediately killed and its liver weighed, and calculations based on such data. It is, however, improbable that the size of the liver determines the amount of the biliary secretion; the great variation which we frequently observed in the secretion from day to day in the same animal is opposed to such an idea.

Effect of the loss of Bile upon the Health of the Animal.

Although an animal may live in perfect health for a considerable time without any bile passing into its alimentary canal, it would appear, from the observations of all who have experimented on the subject, that, even when a fistula has been established without accident, the health sooner or later begins to suffer. Emaciation comes on, and death results from inanition. Much depends on the strength of the animal, which, when vigorous, usually preserve their health.

Dog 7, the retriever sent us by Dr. Kelburne King of Hull, had the operation for biliary fistula performed on April 24, 1868. Notwithstanding the wearing of apparatus for collecting the bile during a period of nearly two months, partial poisoning with corrosive sublimate, purgation with podophylline, and dosing with taraxacum, the animal was on the 11th of September, 1868, when our observations terminated, as strong as it was before the fistula was made; and so far from exhibiting any signs of emaciation, it had gained nearly 4 kilogrammes (8·8 pounds) in weight during the five months it lived, without a drop of bile passing into the intestines. Such a case favours the view of Blondlot and Arnold, as to the inutility of the bile for the purposes of digestion. It is in itself quite sufficient to show that the entrance of bile into the alimentary canal is not essential for the health of the animal, and supports the idea that the bile is a secretion destined to be little more than a mere excretion.

Effect of Muscular Movements upon the Flow of the Bile.

It was frequently observed that when the dogs were taken out of their cages, in which their movements were much circumscribed, and allowed to run about, that during the first half hour or so of their increased movement the amount of bile discharged by the fistula was greatly augmented. This was in all probability due to the bile being more rapidly expelled from the hepatic ducts by the pressure upon the liver of the contracting abdominal muscles, which must, when in action, compress the liver like a sponge, and so expel its contained fluid. This fact is valuable in serving to show that exercise may have an important influence upon the liver. It further points out, however, how utterly fallacious must the results have been had we endeavoured to estimate the daily secretion of bile from collections made during a few minutes at a time, such as were made by Bidder and Schmidt, regarding which, however, we have previously expressed our opinion.

It is unnecessary to dwell upon the importance of the results which the Committee have taken so much pains to arrive at. If the refutation of a widespread error be as important as the establishment of a new truth, the practical advantage of demonstrating that mercury is not a cholagogue cannot be too highly estimated. Although in recent times the administration of

mercurials for hepatic diseases has greatly diminished, their employment is still very general, and in India almost universal. Recent cases demonstrate that long-continued salivation and great loss of health have been produced in the attempt to remove old abscesses or other chronic diseases of this organ, and there are few of its lesions in which it is still not thought advisable to try small or full doses of the drug.

On this subject, however, it is unnecessary to dwell at present; the real question is, whether the evidence is satisfactory, or whether further researches are necessary. On this and many other topics connected with therapeutics, what we require are not unfounded assumptions and vague speculations, but positive knowledge based on unquestionable data; these we have furnished, and consider them amply sufficient to demonstrate the fallacy of the opinions everywhere prevalent as to the cholagogue action of mercury.

It would be vain attempting to convey an adequate idea of the great labour, wearisome repetition of observations, numerous disappointments, and loathsome manipulations which have tested the zeal, endurance, and courage of Drs. Rutherford and Gamgee, on whom the entire labour of the experiments devolved.

The difficulties and expense have been greatly increased by the want of a proper locality for carrying on such investigations, and by the necessity of combating the well-meaning but, we humbly think, mistaken notions of those who maintain that physiologists are not justified in experimenting on animals, even with the objects of determining more accurately the use of poisonous drugs and of preserving the life of man. A very different doctrine might have been expected to exist in a great University like that of Edinburgh; but its Senatus, led astray by the reasoning, we regret to say, of an influential member of the Medical Faculty, unquestionably, by its resolutions, greatly added to the toil and annoyance of the Committee's proceedings. On the other hand our warmest thanks are due to Mr. Nunneley of Leeds, to Dr. Kelburne King of Hull, and Dr. Andrew Buchanan of Glasgow, for their kind assistance in forwarding animals to us.

Last Report on Dredging among the Shetland Isles. *By* J. Gwyn Jeffreys, *F.R.S.*

This was my eighth expedition to the northern extremity of our seas, and occupied the whole of the summer. It was not so successful as those in some previous years, owing to the stormy state of the weather. While my friends in England, Wales, Ireland, and Scotland were enjoying calm sunshine, our climate was exactly the reverse; and the persevering course of the wind (from north-west to south-west) prevented our doing much at sea. This part of the North Atlantic is notoriously subject to broken weather, it being the point where the warm air induced by the Gulf-stream and westerly winds meets the cold air brought down by the arctic current. The fauna of the Shetland waters, however, is by no means exhausted. Every expedition has produced novelties, not only in the Mollusca, but in all other departments of marine zoology.

On the present occasion I obtained, at a depth of 120 fathoms, a living specimen and a larger dead one of a fine species of *Pleurotoma*, *P. carinata* of Bivona. It was originally described as a Calabrian fossil; Jan and Bellardi have given it from the Upper Tertiaries of North Italy, the former under the name of *Fusus modiolus*; and Searles Wood records a single specimen

having been found in the Coralline and another in the Red Crag. Professor Sars and Mr. M'Andrew dredged a few specimens off the coasts of Norway; and the former gave some interesting particulars of the animal, which I have been able to confirm by my own observation. Although allied to *P. nivalis*, and found in the same locality, it has distinct eyes placed on rather prominent stalks or ommatophores, whereas *P. nivalis* has no eyes nor any trace of eye-stalks. On this account Sars proposed the generic name *Typhlomangelia* for the latter species; but it must be borne in mind that *Eulima stenostoma* is also eyeless, and yet is closely related to its congeners and companions, all of which have very conspicuous eyes. It is a somewhat remarkable coincidence that the shell of *E. stenostoma* resembles a large *Achatina acicula*, which is in the same category as regards these so-called organs of sight. The shells of *P. carinata* and *P. nivalis* are easily distinguishable.

Among the rarer and more noteworthy mollusks procured this year were the following:—

Montacuta tumidula, St. Magnus Bay and near Fetlar. Described by me from the Hebrides in the Reports of the Association for 1866.

M. donacina, S. Wood. A single valve from deep water in St. Magnus Bay. Another valve had been dredged by me at Falmouth in 1839. It is a rare Coralline Crag fossil. Its nearest ally is *M. substriata*.

Utriculus globosus, Lovén. A small living specimen occurred this year also in St. Magnus Bay.

U. expansus, Jeffr. A few young specimens again in St. Magnus Bay.

Odostomia Warreni, Thompson. Never having seen this shell in a fresh and perfect state, I considered it (Brit. Conch. iv. p. 143) a variety of *O. obliqua*. But the discovery of live specimens in St. Magnus Bay and near Fetlar enables me to separate the two as distinct species. *O. Warreni* has a shorter spire and more swollen whorls than *O. obliqua*, the suture is deeper, the striæ are much stronger at the base of the shell, the whole surface is covered with most delicate and close-set microscopic spiral lines, and the umbilicus is well developed and deep. The animal of *O. Warreni* has a peculiar foot; this is not plain and rounded at its extremity, as in *O. obliqua*, but is deeply bilobed or forked like the tail of a swallow. No other species of *Odostomia*, so far as I am aware, has a similar foot. One individual spun a fine glutinous thread from the middle of the foot, and kept itself suspended for some time from the surface of the water, with the point of the shell downwards. I found a dead specimen of *O. obliqua* on the same ground with *O. Warreni*.

O. umbilicaris, Malm. A young specimen from St. Magnus Bay, nearly globular, and thus exhibiting the same distinctive characters as the adult.

Siphonodentalium Lofotense and *Cadulus* (or *Loxoporus*) *subfusiformis* were again found, the former being more widely distributed. Both inhabit the Mediterranean; and the latter is a Sicilian and Viennese fossil. I had an excellent opportunity of observing them alive and in active motion. The thread-like and extensile organs by which the Solenoconchia seize their prey are unlike the tentacles of any Gastropod, and their function is quite different. I would call these organs *captacula*, an appropriate word and not less classically formed than *tentacula*.

Leda pernula was dredged, as before, in St. Magnus Bay; but with it was a dead and apparently semifossil valve of *Tellina calcaria*. I must therefore hesitate in considering the one more than the other recent or an inhabitant of the British seas at the present time.

Perhaps *Lamellaria prodita*, Lovén, may be added to the list; but unfortunately the specimen was handled too roughly, and the shell was crushed to

pieces. Its extraordinary size (considerably more than an inch in length) and the depth (110 fathoms) at which it was dredged deserve notice.

Being in the south of Europe last winter I had an opportunity of examining Mediterranean and Adriatic shells; and the result greatly surprised as well as interested me. The dredgings of Capt. Acton (the Commandant of the Italian navy) in the Gulf of Naples, and the extensive collections of Dr. Tiberi at Portici, General Stefanis at Naples, Herr Weinkauf from Algeria, and of Dr. Brusina at Zara, especially yielded a vast quantity of new material for a comparison of the marine testacea of the north and south of Europe. Many of the species having been described (some insufficiently) under different names, the difficulty of identification is considerable; but there is no doubt that a remarkable concordance exists, and to a great extent, between the mollusca which inhabit the deeper parts of the Atlantic and Mediterranean seas from 62° to 36° N. lat. The littoral kinds differ much more—a circumstance which may have been occasioned by climatal conditions. To exemplify the former proposition I subjoin a list of 76 species, usually considered northern, which are common to the North Sea and the Mediterranean, with their principal synonyms.

Names of Species.	*Synonyms.*
Terebratula caput-serpentis, *Linné.*	
Argiope lunifera, *Philippi*	Terebratula cistellula, *Searles Wood.*
Crania anomala, *Müller*	Anomia turbinata, *Poli.*
Pecten septemradiatus, *Müll.*	Ostrea inflexa and O. clavata, *Poli.*
P. aratus, *Gmelin*	P. Bruei, *Payraudeau.*
P. Testæ, *Bivona*	P. furtivus, *Lovén.*
P. striatus, *Müll.*	
P. Hoskynsi, *Forbes*	P. imbrifer, *Lov.*
P. vitreus, *Chemnitz*	P. Gemellarii-filii, *Biondi.*
P. similis, *Laskey*	P. pygmæus, *von Münster.*
Lima Sarsii, *Lov.*	Perhaps L. crassa, *Forbes.*
L. elliptica, *Jeffreys.*	
L. subauriculata, *Montagu.*	
Pinna rudis, *L.*	P. pectinata of some authors, not of *Linné.*
Mytilus phaseolinus, *Ph.*	
Modiolaria discors, *L.*	
Nucula nitida, *G. B. Sowerby.*	
N. tenuis, *Mont.*	N. decipiens, *Ph.*; N. ægeensis, *Forb.*
Leda pygmæa, *v. Münst.*	
Arca obliqua, *Ph.*	A. Korenii, *Danielssen.*
A. nodulosa, *Müll.*	A. scabra, *Poli*; A. aspera, *Ph.*
Lepton nitidum, *Turton.*	
Montacuta ferruginosa, *Mont.*	
Lucina borealis, *L.*	
Axinus Croulinensis, *Jeffr.*	
Cyamium minutum, *Fabricius.*	
Cardium minimum, *Ph.*	C. suecicum, *Lov.*
Astarte sulcata, *Da Costa*	Tellina fusca, *Poli.*
Lucinopsis undata, *Pennant*	Venus incompta, *Ph.*
Tellina balthica, *L.*	T. rubiginosa, *Poli.*
T. pusilla, *Ph.*	
Scrobicularia nitida, *Müll.*	Syndesmya intermedia, *Thompson.*
Lyonsia Norvegica, *Ch.*	Pandorina coruscans, *Scacchi.*
Thracia convexa, *W. Wood*	T. ventricosa, *Ph.*
Neæra rostrata, *Spengler*	N. attenuata, *Forb.*
Xylophaga dorsalis, *Turt.*	
Siphonodentalium Lofotense, *Sars.*	
S. quinquangulare, *Forb.*	Dentalium variabile, *Costa* (Faun. Nap.), not of *Deshayes*; S. pentagonum, *Sars.*

Names of Species.	*Synonyms.*
Cadulus subfusiformis, *Sars.*	
Chiton Hanleyi, *Bean.*	
C. cancellatus, *G. B. Sow.*	
C. cinereus, *L.*	C. asellus, *Sp.*
C. lævis, *Mont.*	C. corallinus, *Risso.*
Tectura virginea, *Müll.*	
Propilidium ancyloïdes, *Forb.*	
Scissurella crispata, *Fleming*	S. aspera, *Ph.*, var.
Trochus cinerarius, *L.*, var. variegata.	
Rissoa reticulata, *Mont.*	R. Beanii, *Hanley.*
R. cimicoïdes, *Forb.*	R. sculpta, *Forbes & Haney,* not of *Philippi.*
R. Zetlandica, *Mont.*	
R. abyssicola, *Forb.*	
R. parva, *Mont.*, and var. interrupta	R. obscura and R. simplex, *Ph.*
R. inconspicua, *Alder.*	
R. albella, *Lov.*	R. Oenensis, *Brusina.*
R. vitrea, *Mont.*	
Jeffreysia diaphana, *Ald.*	Rissoa ? glabra, *Ald.*, not of *Brown.*
J. opalina, *Jeffr.*	
Scalaria Trevelyana, *Leach.*	
Aclis Walleri, *Jeffr.*	
Odostomia clavula, *Lov.*	
O. albella, *Lov.*	
O. umbilicaris, *Malm.*	
O. conspicua, *Ald.*	
O. Scillæ, *Scacchi.*	
O. nitidissima, *Mont.*	
Eulima bilineata, *Ald.*	
Natica catena, *Da C.*	Probably Nerita helicina, *Brocchi.*
Velutina lævigata, *Penn.*	
Cerithium metula, *Lov.*	Mediterranean, *fide Hanley.*
Purpura lapillus, *L.*	
Trophon Mörchi, *Malm*	Bela demersa, *Tiberi.*
Bulla utriculus, *Brocchi*	B. Cranchii, *Leach.*
Philine scabra, *Müll.*	Bullæa angustata, *Biv.*
Aplysia punctata, *Cuvier*	A. hybrida, *J. Sowerby.*
Spirialis retroversus, *Fl.*	Scæa stenogyra, *Ph.*; oceanic.
Clio pyramidata, *L.*	Oceanic.

How is this concordance to be accounted for? I have carefully read again Forbes's elaborate essay "On the Connexion between the distribution of the existing Fauna and Flora of the British Isles, and the Geological changes which have affected their area, especially during the epoch of the Northern Drift" (Memoirs of the Geological Survey of Great Britain, vol. i. 1846); but I cannot find in it a satisfactory solution of the question. He, indeed, mentions the continuance of some "arctic" species in the British seas, the rest having "retired for ever," and that certain other species which he called "Boreal or Celtic" occurred in a fossil state in Sicily; and he states (p. 390) that "in the deepest of the regions of depth in the Ægean" the same representation of a northern fauna as exists in our own seas is maintained, "partly by identical and partly by representative forms." The instances he gives do not support such a view; and I am not a believer in "representative forms." He evidently was not aware of the fact that boreal (not arctic) species still live in the Mediterranean. I, however, fully agree with him that at some former period (which he designates "the newer pliocene epoch") there was an open communication between the Atlantic (according to him the "North Seas") and the Mediterranean, by which the fauna became diffused. I should be inclined to place the Atlantic point of communication at Bordeaux, and that of the Mediterranean at Narbonne, in the line of the Languedoc

Canal, which extends from one coast to the other, and is very little above the present level of the sea. This communication must have been very wide; and it remained open during the glacial epoch, which affected not only the north of Europe, but also Naples, Sicily, and probably Rhodes. Dr. Tiberi showed me a fine valve of *Pecten Islandicus* which had lately been fished up in the Gulf of Naples at a depth of 50 fathoms, and with it a valve of *P. opercularis* quite as large as northern specimens; both the valves were in a semifossil state, and the former was covered with the same Greenland species of *Spirorbis* (*S. cancellatus*, Fabr.) as I noticed on valves of *P. Islandicus* dredged in the Shetland seas at depths varying from 75 to 170 fathoms. Sir Charles Lyell has not adverted, in the last edition of his 'Principles of Geology,' to the remarkable occurrence of such glacial fossils in the Shetland sea-bed, to which I called the attention of geologists in my former Reports as well as in the second volume of 'British Conchology,' p. 58; and he seems to have overlooked the observations of Philippi and Seguenza on the fossils of Calabria and Sicily, when he stated (Princ. Geol. i. p. 298) that "deposits filled with arctic species of marine shells are to be seen in full force on the North American continent ten or more degrees further south than in Europe." Possibly he was misled by one of Forbes's conclusions (Rep. Geol. Surv. p. 402), that "no glacial beds are known in Southern Europe." This, however, was more than twenty years ago. I have myself identified from the Calabrian and Sicilian deposits several high-northern shells (e. g. *Terebratula cranium*, *T. septata*, *Lima excavata*, *Mytilus modiolus*, *Cyprina Islandica*, *Mya truncata*, var. *Uddevallensis*, *Saxicava Norvegica*, *Puncturella Noachina*, *Emarginula crassa*, *Buccinum undatum*, and *Natica affinis* or *clausa*), and from the Rhodian deposits *Terebratula septata* and *Lima Sarsii*.

My old companion, Mr. Waller, picked up on the beach in a small bay on the west coast of Shetland a shell of *Spirula australis*. It is a tropical Cephalopod, and is not unfrequently thrown up by the waves on the southern and western shores of England, Wales, and Ireland, together with exotic species of *Teredo*, *Ianthina*, and *Hyalæa* brought from southern latitudes. Dr. Mörch informs me that several shells of the *Spirula* have this year been found in the Faroe Isles. The transport of such tropical productions to northern latitudes has been usually attributed to the Gulf-stream. It now, however, appears more probable that this is the consequence, not of the direct action and course of the Gulf-stream, but of the prevalence of westerly and south-westerly winds, which waft onwards to northern latitudes, in a northerly and north-easterly direction, the floating objects carried to a certain distance by the Gulf-stream. The direct course of the Gulf-stream has not been observed further north than about 45° N. lat.; from that point it would seem to dwindle into a north-easterly surface drift. A chart will shortly be published by the Admiralty in explanation of this view of the case; and the following papers on the subject ought to be consulted by physical geographers:—Dr. Stark "On the Temperature of the Sea around the coasts of Scotland during the years 1857 and 1858, and the bearing of the facts on the theory that the mild climate of Great Britain during winter is dependent on the Gulf-stream" (Trans. R. S. Edin. 1859), and Capt. Thomas's tables and remarks in Mr. Alex. Buchan's Report "On the Temperature of the Sea on the Coast of Scotland" (Journ. Scottish Meteor. Soc. Oct. 1865). See also 'Br. Conch.' vol. i. (Introd.) pp. xcviii and xcix.

I will add a short summary of the observations recorded in my Reports on Shetland dredgings and in the work last cited.

1. The bathymetrical zones have been too much divided by Risso and subsequent authors. There are two principal zones, littoral and submarine; the nature of the habitat and the supply of food influence the residence and mi-

gration of animals, not the comparative depth of water. *Psammobia costulata* and *Buccinum undatum* are instances in support of this proposition.

2. Specimens or varieties of the same species are larger in the littoral and laminarian zones than in deeper water: e. g. *Mactra solida* and its variety *elliptica*, *Solecurtus candidus*, *Pandora inæquivalvis* and its variety *obtusa* or *pinna*, *Chiton lævis*, *Tectura virginea*, *Trochus zizyphinus*, *Pleurotoma lævigata*, and *Philine aperta*.

3. The size of North-European specimens is usually greater than that of South-European specimens of the same species, e. g. *Pecten septemradiatus*, *P. opercularis*, *Lima hians*, *Mytilus Adriaticus*, *Isocardia cor*, *Astarte sulcata*, *Venus exoleta*, *V. lincta*, *Tellina balaustina*, *Chiton Hanleyi*, *Tectura virginea*, *Natica Alderi*, *Defrancia teres*, *D. purpurea*, and *Bulla utriculus*.

4. The colour of specimens from the greatest depths is not less vivid than of those from shallow water, although each zone has colourless specimens. *Venus ovata*, *Trochus zizyphinus*, *Turritella terebra*, and *Eulima bilineata* may be mentioned as examples. This was lately confirmed by a great authority, Professor Sars, who has given* numerous instances in illustration of it, founded on his son's dredgings at depths varying from 250 to 300 fathoms among the Loffoden Isles. The recent investigations of Dr. W. B. Carpenter and Professor Wyville Thomson in the North Atlantic, by means of the dredge, at much greater depths show also that the shells there procured (e. g. *Venus ovata* and *Columbella haliæeti*) were highly coloured and variegated. In the 'Bulletin of the Museum of Comparative Zoology' at Harvard College, Cambridge, U.S., for 1868, will be found an interesting paper by Count L. F. Pourtales, entitled "Contributions to the Fauna of the Gulf-stream at great depths." He says that at the greatest depths which he explored, reaching to 517 fathoms, "the prevailing colours are white, pink, sometimes playing into orange, and a pale green. Blue was only seen in a small encrusting sponge." And he further remarks that "the deep-sea animals have generally well-developed eyes, larger, if anything, than those of their congeners of shallow water."

5. Mollusca inhabiting deep water have a larger supply of oxygen for the aëration of their gills than those which live in shallow water. See my account of *Columbella haliæeti*.

6. The occurrence of the same species in the North Sea and the Mediterranean results partly from former geological or cosmical conditions, and partly from a communication which once existed between the Bay of Biscay and the Gulf of Lyons.

7. Oceanic or floating shells of exotic species are carried northwards by westerly winds, and not directly by the Gulf-stream, which does not reach our coasts.

8. Land and freshwater mollusca are scarce in Shetland, owing to the scantiness of succulent vegetation for their food, and of lime for the construction of their shells. These are smaller than southern specimens; and the same fact is observable with respect to Shetland insects.

9. Semifossil shells of arctic species (such as *Pecten Islandicus*, *Tellina calcaria*, *Mya truncata*, var. *Uddevallensis*, *Mölleria costulata*, *Trochus cinereus*, and *Trophon clathratus*) are met with on the sea-bottom at considerable depths, and at some distance from land. The only explanation I can offer is a former elevation of the sea-bed whereon these mollusks lived (and which was probably in shallow water), its conversion into dry land, and a subsequent subsidence. Perhaps the sea-bed is still sinking.

10. Species recorded from the Coralline Crag and earlier deposits, and supposed to be extinct, have now been discovered living in the Shetland seas; e. g. *Limopsis aurita*, *Pleurotoma carinata*, and *Columbella haliæeti*. Possibly

* Vidensk.-Selsk. Forhandlinger for 1868, pp. 27 & 28.

Trochus amabilis is another case, assuming that it originated from *Margarita? maculata* of Searles Wood.

Professor Dickie has been good enough to report on some Diatoms from the insides of a quantity of *Echinus Norvegicus*, which were dredged at a depth of 78 fathoms about forty miles from the east coast of Shetland. He says they are chiefly *Navicula didyma, Coscinodiscus excentricus, C. minor, Actinocyclus undulatus*, and *Melosira sulcata*, with fewer of *M. nummuloïdes* and *Nitzschia angularis*, all marine; also a few freshwater *Cocconema lanceolatum, Surirella minuta*, and fragments of a *Pinnularia*. And he adds that long ago he recorded the occurrence of freshwater Diatomaceæ mixed with marine species from the stomachs of *Ascidiæ* taken in deep water off Aberdeen. The freshwater Diatoms must evidently have been carried by a stream into the sea, and transported by the tide to the place where they sunk to the bottom, and were swallowed by the indiscriminating *Echini* and *Ascidiæ*. Diatoms inhabit the surface only of the water, and *Globigerina* and other Foraminifera not of a fixed or sessile nature have been observed by Major Owen and myself to float when alive within a few inches from the surface. Dr. Wallich found the microscopic organisms which he called coccospheres "profusely in a living, or perhaps it would be more safe to say a recent, condition in material collected at the surface of the open seas of the tropics." Coccospheres and free Foraminifera cover the bed of the Atlantic at enormous depths. The occurrence, therefore, of such organisms on the floor of the ocean at such depths does not prove that they ever lived there. I should rather be inclined to believe that they dropped to the bottom of the sea when dead or after having passed through the stomachs of other animals which had fed on them.

A few small fishes were caught in the dredge at depths of from 90 to 100 fathoms. Dr. Günther reports that they belong to the undermentioned species:—*Callionymus maculatus* (Bonap.), *Gobius Jeffreysii* (Günth.), young, *Cyclopterus lumpus* (L.), young, *Lepadogaster bimaculatus* (Penn.), and *Rhombus Norvegicus* (Günth.), young. He remarks that the last-named species is new to the British fauna, having been hitherto known from the coast of Norway only.

Mr. Norman will report on the Crustacea, Tunicata, Polyzoa, Hydrozoa, Echinoderms, Actinozoa, and Sponges, Dr. M'Intosh on the Annelids, and Mr. Waller on the Foraminifera.

Mollusca inhabiting the Shetland Isles and the adjacent seas. (See Tables of distribution in 'British Conchology,' vols. i.–iv.)

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
MARINE.			
BRACHIOPODA.			
Terebratula cranium, *Müller*	—	—	Vigo (M'Andrew).
caput-serpentis, *Linné*	—	—	
†Terebratella Spitzbergensis, *Davidson*	—		Possibly fossil.
†Rhynchonella psittacea, *L.*	—		Possibly fossil.
Argiope lunifera, *Philippi*	—	—	*Terebratula cistellula*, S. Wood.
Crania anomala, *Müller*	—	—	*Anomia turbinata*, Poli.
6	6	4	

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
CONCHIFERA.			
Anomia ephippium, *L.*	—	—	
patelliformis, *L.*	—	—	
Ostrea edulis, *L.*	—	—	
Pecten pusio, *L.*	—	—	
opercularis, *L.*	—	—	
septemradiatus, *Müll.*	—	—	
†aratus, *Gmelin*	—	—	*P. Bruei*, Payraudeau.
tigrinus, *Müll.*	—	—	
†Testæ, *Bivona*	—	—	
striatus, *Müll.*	—	—	
†vitreus, *Chemnitz*	—	—	*P. Gemellarii-filii*, Biondi.
similis, *Laskey*	—	—	
maximus, *L.*	—	—	
†Lima Sarsii, *Lov.*	—	—	
†elliptica, *Jeffreys*	—	—	
subauriculata, *Mont.*	—	—	
Loscombii, *G. B. Sowerby*	—	—	
Pinna rudis, *L.*		—	*P. pectinata* of some authors, not of Linné.
Mytilus edulis, *L.*	—	—	
modiolus, *L.*	—		Fossil in Calabria and Sicily.
Adriaticus, *Lamarck*	—	—	
phaseolinus, *Ph.*	—	—	
Modiolaria marmorata, *Forbes*	—	—	
discors, *L.*	—	—	
nigra, *Gray*	—		
Crenella decussata, *Mont.*	—		
Nucula nucleus, *L.*	—	—	
nitida, *G. B. Sow.*	—	—	
tenuis, *Mont.*	—	—	
Leda pygmæa, *von Münster*	—	—	
minuta, *Müll.*	—		
†pernula, *Müll.*	—		Possibly fossil.
†Limopsis aurita, *Brocchi*			Fossil in the Coralline Crag, and in miocene and pliocene beds on the Continent. Perhaps an arctic species.
Pectunculus glycymeris, *L.*	—	—	
Arca pectunculoïdes, *Scacchi*	—	—	
†obliqua, *Ph.*	—	—	
†nodulosa, *Müll.*	—	—	*A. scabra*, Poli; *A. aspera*, Ph.
tetragona, *Poli*	—	—	
Lepton nitidum, *Turton*	—	—	
Clarkiæ, *Clark*			
Montacuta substriata, *Mont.*	—	—	
†donacina, *S. Wood*			A Coralline Crag fossil.
bidentata, *Mont.*	—	—	
†tumidula, *Jeffr.*	—		
ferruginosa, *Mont.*	—	—	
Lasæa rubra, *Mont.*	—	—	
Kellia suborbicularis, *Mont.*	—	—	
†cycladia, *S. Wood*		—	Coralline Crag.
Lucina spirifera, *Mont.*	—	—	
borealis, *L.*	—	—	

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
Axinus flexuosus, *Mont.*	—	—	
†Croulinensis, *Jeffr.*	—	—	*A. pusillus*, Sars.
ferruginosus, *Forb.*	—	—	
Cyamium minutum, *Fabricius*	—	—	
Cardium echinatum, *L.*	—	—	
exiguum, *Gmelin*	—	—	
fasciatum, *Mont.*	—	—	
nodosum, *Turt.*	—	—	
edule, *L.*	—	—	
minimum, *Ph.*	—	—	
Norvegicum, *Spengler*	—	—	
Isocardia cor, *L.*	—	—	
Cyprina Islandica, *L.*	—		Fossil at Nice and in Sicily.
Astarte sulcata, *Da Costa*	—	—	
compressa, *Mont.*	—		
triangularis, *Mont.*		—	
Circe minima, *Mont.*	—	—	
Venus exoleta, *L.*	—	—	
lincta, *Pulteney*	—	—	
fasciata, *Da C.*	—	—	
Casina, *L.*	—	—	
ovata, *Pennant*	—	—	
gallina, *L.*	—	—	
Tapes virgineus, *auct.*	—	—	Probably not *Venus virginea* of Linné.
pullastra, *Mont.*	—	—	
Tapes decussatus, *L.*		—	Fossil in Sweden and Norway.
Lucinopsis undata, *Penn.*	—	—	
? Gastrana fragilis, *L.*	?—	—	Zetlandic on the authority of Forbes, and Norwegian on that of M'Andrew.
Tellina balaustina, *L.*		—	
crassa, *Penn.*	—	—	
balthica, *L.*	—	—	
tenuis, *Da C.*	—	—	
fabula, *Gronovius*	—	—	
donacina, *L.*		—	
pusilla, *Ph.*	—	—	
Psammobia tellinella, *Lam.*	—	—	
costulata, *Turt.*	—	—	
Ferröensis, *Ch.*	—	—	
Mactra solida, *L.*	—	—	
subtruncata, *Da C.*	—	—	
stultorum, *L.*	—	—	
Lutraria elliptica, *Lam.*	—	—	
Scrobicularia prismatica, *Mont.*	—	—	
nitida, *Müll.*	—	—	
alba, *W. Wood*	—	—	
Solecurtus candidus, *Renier*		—	Boulder-clay of Caithness (Peach).
antiquatus, *Pult.*	—	—	
Solen pellucidus, *Penn.*	—	—	
ensis, *L.*	—	—	
siliqua, *L.*	—	—	
Pandora inæquivalvis, *L.*	—	—	The northern and deep-water variety is *Solen pinna* of Montagu = *P. obtusa*, Leach.

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
Lyonsia Norvegica, *Ch.*	—	—	
Thracia prætenuis, *Pult.*	—	—	
papyracea, *Poli*	—	—	*Amphidesma phaseolina,* Lam.
convexa, *W. Wood*	—	—	
distorta, *Mont.*	—	—	
Poromya granulata, *Nyst* and *Westendorp*	—	—	
Neæra abbreviata, *Forb.*	—	—	
costellata, *Deshayes*	—	—	
†rostrata, *Sp.*	—	—	
cuspidata, *Olivi*	—	—	
Corbula gibba, *Ol.*	—	—	
Mya truncata, *L.*	—		Fossil in Sicily.
†Panopea plicata, *Mont.*	—	—	
Saxicava Norvegica, *Sp.*	—		Shetland (M'Andrew). Fossil in Sicily.
rugosa, *L.*	—	—	
Pholas crispata, *L.*	—	?—	Marseilles (Matheron); Fossil?
Xylophaga dorsalis, *Turt.*	—	—	
Teredo Norvegica, *Sp.*	—	—	
megotara, *Hanley*	—	—	
126	110	107	
SOLENOCONCHIA.			
Dentalium entalis, *L.*	—	?—	
†abyssorum, *Sars*	—		
†Siphonodentalium Lofotense, *Sars*	—	—	
†Cadulus subfusiformis, *Sars*	—	—	
4	4	3	
GASTROPODA.			
Chiton fascicularis, *L.*	—	—	
Hanleyi, *Bean*	—	—	Dredged by Capt. Acton in the Gulf of Naples!
cancellatus, *Leach?*	—	—	
cinereus, *L.*	—	—	
albus, *L.*	—		
marginatus, *Penn.*	—	—	
ruber, *Lowe*	—		
lævis, *Mont*	—	—	
marmoreus, *Fabr.*	—		
Patella vulgata, *L.*	—	—	
Helcion pellucidum, *L.*	—	—	
Tectura testudinalis, *Müll.*	—		
virginea, *Müll.*	—	—	
fulva, *Müll.*	—		
†Lepeta cæca, *Müll.*	—		
Propilidium ancyloïdes, *Forb.*	—	—	
Puncturella Noachina, *L.*	—		Fossil in Sicily.
Emarginula fissura, *L.*	—	—	
crassa, *J. Sowerby*	—		Fossil in Calabria as *E. decussata* (Ph.), and in Sicily (Seguenza).
?Fissurella græca, *L.*		—	Zetlandic on Forbes's authority.

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
Capulus Hungaricus, *L.*	—	—	
Scissurella crispata, *Fleming*	—	—	*S. aspera*, Ph., appears to be the southern form or variety.
Cyclostrema nitens, *Ph.*	—	—	
serpuloïdes, *Mont.*	—	—	
Trochus helicinus, *Fabr.*	—		
Grœnlandicus, *Ch.*	—		
†amabilis, *Jeffr.*			
magus, *L.*	—		
tumidus, *Mont.*	—	—	
cinerarius, *L.*	—	—	The southern form is the variety *variegata.*
Montacuti, *W. Wood*		—	
millegranus, *Ph.*	—	—	
zizyphinus, *L.*	—	—	
occidentalis, *Mighels*	—		
Lacuna crassior, *Mont.*			Probably arctic.
divaricatus, *Fabr.*	—	—	Gulf of Gascony.
puteolus, *Turt.*	—	—	Corunna and Vigo (M'Andrew).
pallidula, *Da C.*	—	—	Arcachon (Fischer).
Littorina obtusata, *L.*	—	—	North of Spain, and Vigo; the Mediterranean localities are doubtful.
neritoïdes, *L.*	—	—	
rudis, *Maton*	—	—	Corunna and Lisbon (M'Andrew); Algiers (J. W. Flower); Adriatic (Brusina).
litorea, *L.*	—	—	Corunna and Lisbon (M'Andrew); the Mediterranean and Adriatic localities are doubtful.
Rissoa reticulata, *Mont.*	—	—	
cimicoïdes, *Forb.*	—	—	
†Jeffreysi, *Waller*	—	—	Gulf of Gascony (Marquis de Folin)!
punctura, *Mont.*	—	—	
abyssicola, *Forb.*	—	—	
Zetlandica, *Mont.*	—	—	
costata, *Adams*	—	—	Shetland, *fide* Barlee.
parva, *Da C.*	—	—	
inconspicüa, *Ald.*	—	—	
†albella, *Lov.*	—	—	Adriatic, as *R. Oenensis* (Brusina).
membranacea, *Ad.*	—	—	
violacea, *Desmarets*	—	—	
striata, *Ad.*	—	—	
proxima, *Ald.*		—	
vitrea, *Mont.*	—	—	Shetland, *fide* Fleming.
soluta, *Ph.*	—	—	
semistriata, *Mont.*	—	—	Shetland, *fide* Barlee.
cingillus, *Mont.*	—	—	
Hydrobia ulvæ, *Penn.*	—	—	*Turbo stagnalis*, L.
Jeffreysia diaphana, *Ald.*		—	
opalina, *Jeffr.*		—	
globularis, *Jeffr.*			
Skenea planorbis, *Fabr.*	—	—	
Homalogyra atomus, *Ph.*	—	—	
rota, *F. & H.*	—	—	
Cæcum glabrum, *Mont.*	—	—	

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
Turritella terebra, *L.*	—	—	
Scalaria Trevelyana, *Leach*	—	—	
clathratula, *Ad.*	—	—	
Aclis unica, *Mont.*		—	Dalmatia (Brusina).
ascaris, *Turt.*	—	—	
supranitida, *S. Wood*	—	—	
†Walleri, *Jeffr.*	—	—	Gulf of Naples (Stefanis).
Gulsonæ, *Cl.*			Vigo Bay (M'Andrew).
†Odostomia minima, *Jeffr.*			
nivosa, *Mont.*			
clavula, *Lov.*	—	—	Gulf of Naples (Tiberi and Acton).
†Lukisi, *Jeffr.*		—	Dalmatia (Brusina); Sicily (Tiberi).
†albella, *Lov.*	—	—	Dalmatia (Brusina).
pallida, *Mont.*	—	—	*O. Novegradensis*, Brus.
conoïdea, *Brocchi*	—	—	
†umbilicaris, *Malm*	—	—	Gulf of Naples (Acton).
acuta, *Jeffr.*	—	—	
conspicua, *Ald.*	—	—	
unidentata, *Mont.*	—		Loire-Inférieure (Cailliaud).
turrita, *Hanl.*	—	—	
insculpta, *Mont.*	—		Brittany (Cailliaud and Taslé).
†diaphana, *Jeffr.*		—	
obliqua, *Ald.*	—	—	Dalmatia (Brusina); Naples (Stefanis).
Warreni, *Thompson*		—	
indistincta, *Mont.*	—	—	
interstincta, *Mont.*	—	—	Adriatic (Stossich).
spiralis, *Mont.*	—	—	
eximia, *Jeffr.*	—		
scalaris, *Ph.*	—	—	
rufa, *Ph.*	—	—	
Scillæ, *Scacchi*	—	—	Gulf of Naples (Stefanis); Madeira and Canaries (M'Andrew).
acicula, *Ph.*	—	—	
nitidissima, *Mont.*	—	—	Adriatic and Mediterranean.
Stilifer Turtoni, *Broderip*	—	—	Canary Isles (M'Andrew).
Eulima polita, *L.*	—	—	
intermedia, *Cantraine*	—	—	
distorta, *Desh.*, sec. *Ph.*	—	—	*E. Philippii*, Weinkauff.
†stenostoma, *Jeffr.*	—		
?subulata, *Donovan*	?—	—	Shetland, *fide* Forbes; Norway, *fide* Lovén and Danielssen.
bilineata, *Ald.*	—	—	Adriatic and Mediterranean.
Natica Islandica, *Gm.*	—		
Grœnlandica, *Beck.*	—		
sordida, *Ph.*		—	Perhaps *N. fusca*, De Blainville.
catena, *Da C.*	—	—	
Alderi, *Forb.*	—	—	
Montacuti, *Forb.*	—		Fossil in Sicily.
Lamellaria perspicua, *L.*	—	—	
Velutina plicatilis, *Müll.*	—		
lævigata, *Penn.*	—	—	
†Torellia vestita, *Jeffr.*	—		
Trichotropis borealis, *Brod. & Sow.*	—		
Aporrhaïs pes-pelecani, *L.*	—	—	

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
Aporrhais Macandreæ, *Jeffr.*	—		Fossil in Sicily.
Cerithium metula, *Lov.*	—	—	Villafranca (Hanley).
perversum, *L.*	—	—	
Cerithiopsis tubercularis, *Mont.*	—	—	
Metaxa, *Delle Chiaje*		—	Shetland, *fide* Barlee.
†costulata, *Möller*	—		
Purpura lapillus, *L.*	—	—	
Buccinum undatum, *L.*	—	—	Gulf of Lyons (Martin). Fossil in Sicily and Calabria.
Humphreysianum, *Bennett*	—		Fossil in Sicily and Calabria.
Buccinopsis Dalei, *J. Sow.*	—		
Trophon Barvicensis, *Johnston*	—		
truncatus, *Ström*	—		
Fusus antiquus, *L.*	—	—	
Norvegicus, *Ch.*	—		
Turtoni, *Bean*	—		An embryo capsule only in Shetland.
†Islandicus, *Ch.*	—		
gracilis, *Da C.*	—	—	Bay of Biscay.
propinquus, *Ald.*	—		
Berniciensis, *King*	—	—	Arcachon (Lafont)!
Nassa reticulata, *L.*	—	—	
incrassata, *Str.*	—	—	
†Columbella haliæeti, *Jeffr.*	—		Fossil in the Sicilian and other tertiary beds.
nana, *Lov.*	—		Genus *Thesbia.*
Defrancia teres, *Forb.*	—	—	
gracilis, *Mont.*		—	
Leufroyi, *Michaud*	—	—	
linearis, *Mont.*	—	—	
†reticulata, *Ren.*	—	—	
purpurea, *Mont.*	—	—	
Pleurotoma costata, *Don.*	—	—	
brachystoma, *Ph.*	—	—	
nebula, *Mont.*	—	—	The variety *elongata* is the Shetland form.
†nivalis, *Lov.*	—		Fossil in the Coralline Crag.
†carinata, *Bir.*	—		Fossil in the Vienna basin, Italy, and the Crag.
turricula, *Mont.*	—		North of France.
Trevelyana, *Turt.*	—		
Marginella lævis, *Don.*		—	
Cypræa Europæa, *Mont.*	—	—	
Cylichna acuminata, *Bruguière*	—	—	
nitidula, *Lov.*	—	—	Gulf of Naples (Stefanis).
umbilicata, *Mont.*	—	—	
cylindracea, *Penn.*	—	—	
†alba, *Brown*	—		
Utriculus mammillatus, *Ph.*	—	—	
truncatulus, *Brug.*	—	—	
obtusus, *Mont.*	—	—	Bay of Biscay and the Adriatic.
†expansus, *Jeffr.*	—		
hyalinus, *Turt.*	—	—	
†globosus, *Lov.*	—		*Utriculopsis vitrea*, Sars.

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
Acera bullata, *Müll.*	—	—	
Actæon tornatilis, *L.*	—	—	
Bulla utriculus, *Brocchi*	—	—	
Scaphander lignarius, *L.*	—	—	
†librarius, *Lov.*	—		
Philine scabra, *Müll.*	—	—	
catena, *Mont.*		—	Shetland, *fide* Barlee.
†angulata, *Jeffr.*			
quadrata, *S. Wood*	—		
punctata, *Cl.*	—	—	
pruinosa, *Cl.*	—	—	Dalmatia (Brusina).
†nitida, *Jeffr.*			
aperta, *L.*	—	—	
Aplysia punctata, *Cuv.*	—	—	*A. hybrida*, J. Sow.
Pleurophyllidia Loveni, *Bergh*	—		*Diphyllidia lineata*, Forbes and Hanley (not of Otto).
Doris tuberculata, *Cuv.*	—	—	
Zetlandica, *Alder & Hancock*			
Johnstoni, *A. & H.*	—		
repanda, *A. & H.*	—		
? muricata, *Müll.*	—		Alder.
bilamellata, *L.*	—		*D. fusca*, Müll.
pilosa, *Müll.*	—	—	
Goniodoris nodosa, *Mont.*	—		
Triopa claviger, *Müll.*	—		
Polycera quadrilineata, *Müll.*	—	—	
ocellata, *A. & H.*	—		Norman.
Ancula cristata, *Ald.*	—		
Idalia Leachii, *A. & H.*			Norman.
inæqualis, *Forb.*			
Tritonia Hombergi, *Cuv.*	—	—	
plebeia, *Johnst.*	—		
Ægirus punctilucens, *D'Orbigny*	—	—	
Lomanotus marmoratus, *A. & H.*			Peach.
Dendronotus arborescens, *Müll.*	—		
Doto fragilis, *Forb.*	—		
coronata, *Gm.*	—	—	
cuspidata, *A. & H.*			
Eolis papillosa, *L.*	—		
coronata, *Forb.*	—		
rufibranchialis, *Johnst.*	—		
Landsburgi, *A. & H.*			Norman.
pellucida, *A. & H.*	—		Norman. Not *Doris pellucida*, Risso.
alba, *A. & H.*	—		
olivacea, *A. & H.*			
pustulata, *A. & H.*			
aurantiaca, *A. & H.*	—		Norman.
? tricolor, *Forb.*	—		Alder.
picta, *A. & H.*			Norman.
despecta, *Johnst.*			
Hermæa bifida, *Mont.*	—		
Embletonia minuta, *Forbes & Goodsir*			
Antiopa cristata, *Delle Ch.*		—	Norman.
Limapontia nigra, *Johnst.*	—		
Melampus bidentatus, *Mont.*		—	
223	188	140	

Name of Species.	Northern.	Southern.	Remarks as to distribution and synonymy.
PTEROPODA.			
Spirialis retroversus, *Fl.*	—	—	
†Clio pyramidata, *L.*	—	—	
†infundibulum, *S. Wood*		—	Coralline Crag. Perhaps *C. caudata* of Linné and *Cleodora compressa* of Souleyet.
3	2	3	
CEPHALOPODA.			
Rossia macrosoma, *Delle Ch.*	—	—	
†?glaucopis, *Lov.*	—		Lovén.
†papillifera, *Jeffr.*, sp. n.			
Sepiola Rondeleti, *Leach*	—	—	Maclaurin.
Sepia officinalis, *L.*	—	—	
Eledone cirrosa, *Linn.*	—		Maclaurin.
6	5	3	
LAND AND FRESHWATER.			
CONCHIFERA.			
Pisidium nitidum, *Jenyns*	—	—	
roseum, *Scholtz*	—	—	
2	2	2	
GASTROPODA.			
Planorbis nautileus, *L.*	—	—	
glaber, *Jeffr.*	—	—	
contortus, *L.*	—	—	
Limnæa peregra, *Müll.*	—	—	
truncatula, *Müll.*	—	—	
Arion ater, *L.*	—	—	
Limax agrestis, *L.*	—	—	
lævis, *Müll.*	—	—	*L. brunneus*, F. & H.; not Draparnaud's species of that name.
tenellus, *Müll.*	—		
marginatus, *Müll.*	—		*L. arborum*, Bouchard-Chantereaux.
maximus, *L.*	—	—	
Succinea putris, *L.*	—	—	
elegans, *Risso*	—	—	
Vitrina pellucida, *Müll.*	—	—	
Zonites cellarius, *Müll.*	—	—	
alliarius, *Miller*	—	—	
Helix nemoralis, *L.*, var. hortensis	—	—	
arbustorum, *L.*	—	—	
rotundata, *Müll.*	—	—	
Pupa umbilicata, *Draparnaud*	—	—	
Clausilia rugosa, *Dr.*	—	—	
Cochlicopa lubrica, *Müll.*	—	—	
22	22	20	

Summary.

	Shetland.	Northern.	Southern.	Total British.	Remarks.
MARINE.					
Brachiopoda	6	6	4	8	
Conchifera	126	110	107	167	
Solenoconchia	4	4	3	5	
Gastropoda	223	188	140	359	The last figure includes 111 Nudibranchs.
Pteropoda	3	2	3	3	The number of marine species in Lovén's 'Index' of Scandinavian mollusca is 345, including 40 Nudibranchs.
Cephalopoda	6	5	3	12	
	368	315	260	554	
LAND AND FRESHWATER.					
Conchifera	2	2	2	15	
Gastropoda	22	22	20	109	
	392	339	282	678	

Obs. The Shetland Nudibranchs and Cephalopods have not been sufficiently investigated. Lovén's 'Index' and a further list of Swedish Nudibranchs which he lately sent me contain 60 species of that order, out of which 25 only have been identified as Zetlandic. He also gives 9 species of Cephalopods, of which 5 only are Zetlandic. The southern distribution of our Nudibranchs is very little known. For the preparation of the present list of Nudibranchs I am in a great measure indebted to the late Mr. Alder and to Mr. Norman. Forty-eight species of mollusca (marked †) have been discovered in the Shetland seas since the publication of Forbes & Hanley's 'History of British Mollusca and their Shells.'

Shetland Final Dredging Report.—Part II. *On the Crustacea, Tunicata, Polyzoa, Echinodermata, Actinozoa, Hydrozoa, and Porifera. By the* Rev. ALFRED MERLE NORMAN, *M.A.*

THE especial object with which the Shetland dredging was recently undertaken, under the auspices of the British Association, was the examination of the fauna of the deep water which surrounds that most northern group of our islands. The abyss of the sea there approaches near to land at a depth rapidly descending to eighty or one hundred, and subsequently reaching many hundred fathoms. The sea-bottom at such a depth would never have been laid bare during those two great upheavals of the earth's surface which appear to have been the last great geological oscillations over the area of the north-west of Europe. At a time when all the channels and sea which now separate our islands from each other, and from the rest of Europe, were raised high and dry above the level of the ocean, and the whole formed part of one great continent, the sea, if the calculations as to the extent of that elevation are anything like the truth, must still have broken on the rocky shores of the

imposingly bold promontory of Shetland, and the forefathers of at least a large proportion of its present inhabitants must have lived and died in the same spots which they now occupy.

Before the recent investigation was commenced, the dredgings of Mr. Jeffreys and the late Mr. Barlee had resulted in procuring many northern species of Mollusca in Shetland, which were not before supposed to range so far south. Moreover, the long lines of the Haaf fishermen had brought up some strangers from the deep, and had made known to Jameson, Fleming, and others the existence of a fauna of a widely different character from that of other portions of the British coast. Lastly, the cruise of Mr. M'Andrew's yacht enabled the late Professor E. Forbes to acquaint himself with many Echinodermata and other animals of peculiar interest. These combined circumstances made us anxious that the invertebrata of this portion of our islands should be thoroughly investigated, and led to the appointment by the British Association of a Committee to prosecute such researches. It is only right, however, that it should be known that the money which has from time to time been voted by the Association to this Committee has only consisted of grants in aid*. Dredging in the open waters of the Atlantic at considerable distances from land necessitates the employment of a vessel of some size, and consequently entails a not inconsiderable outlay. That outlay has been mainly borne by Mr. Jeffreys, who has been the leader in the whole undertaking. Mr. Leckenby, of Scarborough, has also contributed largely towards the expenses; and other members of the Committee, who have taken part in the expeditions, have similarly aided, if in much smaller sums, at least not less willingly in proportion to their means. But my object in referring to this matter is to let it be known that the light which is now thrown upon the fauna of this portion of our seas, together with any value which this present Report may possess, is chiefly due to the liberality in the cause of science of the two naturalists whose names have been mentioned.

The marine fauna of Shetland has now been proved to be extremely rich. The sea there would seem to be in an especial manner the meeting-place of northern and southern types. Many arctic forms not known further to the south are here found associated with numerous Mediterranean species which do not reach the Scandinavian coast, and some of which are remarkable as not having as yet been found at any intermediate habitat between the extreme south of Europe and Shetland.

The distribution of animal life around our coasts appears for the most part to have followed the direction south, west, north, east. It would seem that comparatively very few (if any) southern species have made their way far north through the straits of Dover, which may probably be accounted for by the fact that that channel has, geologically speaking, been only a short time open. As a rule southern species are to be seen at a higher latitude on the western than they are on the eastern coasts. There are, however, some apparent, but only apparent, exceptions. These consist of animals known on the north-east coast of Scotland, which we should not have expected to meet with there. On examining into the probable cause of their migration to this district, I am led to believe that they have made their way thither round the western and northern, and down the eastern coasts to their present habitats, and not up the eastern coast as might at first have been supposed. For example, *Cerithium perversum*, *Phasianella pulla*, *Fissurella Græca*, *Tellina balaustina*, *Callianassa subterranea*, *Palmipes placenta*, *Amphiura brachiata*, &c.

* The dredging of the first two years here reported on (1861 and 1862) was carried on without any aid from the British Association.

have been found in the Moray Firth, but are wholly unknown on the eastern coast of England. Moreover, many species have been recorded on the Norwegian coast, though never found on the eastern shores of England, and therefore may be presumed to have migrated thither up the western side of Great Britain and round the north of Scotland; as examples of such species may be cited *Pleurotoma striolata*, *attenuata*, and *septangularis*, *Cerithiopsis tubercularis*, *Cerithium reticulatum* and *perversum*, *Rissoa violacea*, *Pholas dactylus*, *Solen vagina*, *Psammobia costulata*, *Gastrana fragilis*, *Isocardia cor*, *Cardium aculeatum*, *Lepton squamosum*, *Xantho rivulosus*, *Portunus arcuatus*, *Gebia deltura*, &c. On the other hand, while northern forms do not extend southward on the east coast beyond Yorkshire and the Dogger Bank, on the western coasts they in many instances have a range southwards to the Nymph Bank, off Cork, and even to the Mediterranean sea. Inasmuch, therefore, as migration northwards has for the most part taken place by way of the Hebrides and Shetland, a southern form which may be found in the Gulf of Christiania or neighbouring part of Scandinavia, though at a point of latitude considerably further to the south than Shetland, may be regarded practically with respect to distribution to be further north, and a northern species at Shetland as further south in its course of migration. In the preparation, therefore, of the Tables IV. and VII. I have regarded the whole of the Scandinavian sea as though it was to the north of Shetland, notwithstanding that the latter is geographically situated in about the same latitude as Bergen.

As has been already stated, the chief aim of the Dredging Committee was to thoroughly examine the invertebrata of the deep sea. This purpose was never lost sight of, and the dredge was rarely let down in the Voes or other shallow water except when we were driven there by stress of weather; nor was it possible to find much leisure, amid the constant labour entailed by the examination and preparation of the animals procured by the dredge, to devote to the littoral zone. Notwithstanding, therefore, the great length of the present catalogue (which shows the fauna in almost every branch to be more rich than that of any other portion of the British coast which has been carefully examined by competent naturalists) there cannot be a question that numerous and interesting discoveries will reward the future investigations of zoologists near the shore as well as in the open sea. For with regard to the latter, our repeated dredgings in these northern waters have only sent us home each time more fully convinced how much remains to be done before we can attain anything like a complete knowledge of the animals which inhabit them. We never tried a new locality a few miles distant from that which we were before examining that we did not meet with species which had been previously unnoticed: in fact the Shetland seas appear to afford an inexhaustible treasury of rare animals in every department of zoology.

While some species are extremely widely diffused, though numerically scarce, throughout the province, others are common everywhere, and others again apparently excessively limited in their distribution as well as very rare when found. But one of the most remarkable features in the distribution of life in the Shetland Sea is the extraordinarily circumscribed habitat, but at the same time the local profusion, of many species. It will not be without interest to give a few examples of this. Many Crustacea, as *Nika edulis*, *Doryphorus Gordoni*, *Gastrosaccus sanctus*, &c., occurred on one occasion in one spot in considerable numbers, but were scarcely ever (if ever) seen again. Forty miles east of the Whalsey Skerries *Echinus Norvegicus* was in such extraordinary profusion that the dredge came up again and again literally almost filled with it; but though occurring in many other localities, it was,

save in this one instance, comparatively uncommon. Near the same spot *Antedon Sarsii* was brought up in thousands, yet, except in that one day's dredging, I never was fortunate enough to meet with the species. In this same neighbourhood *Ophiura Sarsii* was found very abundantly, but it was scarcely ever seen again during these dredgings. *Cidaris papillata* and *Spatangus meridionalis* appeared to be confined to one limited area to the north of Unst, yet there they were to be met with in considerable numbers. Similarly *Tealia digitata* was chiefly found in one particular spot; and the same is true of *Ascidia obliqua*, *A. sordida*, *Eschara lorea* and *lævis*, *Cellepora attenuata*, *Tessarodoma gracile*, *Palmicellaria elegans*, *Hornera borealis* and *violacea*, *Zoanthus papillosus*, *Sidisia Barleeii*, *Pennatula phosphorea*, *Tubularia attenuata*, *Quasillina brevis*, *Phakellia robusta*, *Isodictya fimbriata*, *Oceanapia Jeffreysii*, &c., all of which, though dredged occasionally elsewhere, were chiefly to be found in one circumscribed area, where they appeared to be very common, and in some instances to live in the most astounding quantities. When cases of remarkable local distribution occur in channels or bays the circumstance is not unexpected, but it is different when we are dredging in the wide expanse of the Atlantic with *apparently* no causes at work to make such differences in the nature of the sea-bottom, which around Shetland is in general of nearly uniform though gradually increasing depth, as would render different positions peculiarly fitted for the life of different species. Yet this would seem in a most marked degree to be the case. The nature of the sea-bed on the Haaf is continually changing, and the character of the inhabitants varies with it. At one moment the dredge is scraping over hard stony ground calculated to tear the nets to pieces, at the next it is sunk deep in fine sand or in an unctuous mud. When the dredge is hauled up it will be often found that while down it has at first travelled over a soft bottom and thence brought up in the sand some extremely interesting species, perhaps in profusion, while subsequently it has been dragged over hard ground and the stones which it has thence collected have crushed to pieces the delicate organisms which lay below them in the net. We at once tack and endeavour again to strike the spot where we had first let down the dredge—no easy matter certainly in the open sea, where no bearings can be taken from the land; the whole day is spent, perhaps many days are spent, in the search for that spot, but *Ulocyathus arcticus* or *Trochus amabilis* declines again to show us its pretty face.

It may be well to mention that the term "Haaf," which constantly occurs in this Report, means the *open sea*, and the Shetland fishermen, more especially those of the "Out" or "Whalsey Skerries," speak of the "inner," "middle," or "outer Haaf," according to the distance of the fishing-ground from land. The "outer Haaf" to the east of the Whalsey Skerries is about forty miles from those rocky islets, and fifty-five or sixty miles from the mainland.

In the catalogue of species which follows in this Report I have, in the case of those animals which have only occurred once, generally appended the date of the year in which they were discovered. The following account of the naturalists who accompanied the expeditions in the different years will enable the reader to assign the credit of each discovery to the right persons. Many invertebrata which were preserved during the years when I was not myself present with the Committee, and belong to the classes on which I report, were kindly placed in my hands by Mr. Jeffreys. In the notes which follow, the specimens having been actually examined by myself, I hold myself responsible for the correctness of the identification of the species in all cases, except where the locality or note is contained within inverted commas, where

the determination of the species rests upon the authority of the naturalist whose name follows the quotation.

1861. Mr. Jeffreys, Mr. Waller, and myself. The dredging this year was chiefly carried on from the Whalsey Skerries, where the Lighthouse was made our headquarters; but a short cruise was taken, just before the homeward voyage, to the ground to the north of Unst, which in later years proved so productive. Vessel, the yacht 'Osprey.'

1862. Mr. Jeffreys and Professor Allman. The expedition came to a premature and unfortunate termination. The vessel which had been chartered, having been caught in a heavy gale at sea, had her rudder-post carried away, and thus became disabled. Professor Allman, however, succeeded in procuring several Hydrozoa new to science.

1863. Mr. Jeffreys, Mr. Waller, Mr. R. Dawson, and myself. A steamer was this year engaged in the work, and the dredging was in the directions north, north-east, and east of Unst.

1864. Mr. Jeffreys, Mr. Waller, and Mr. Peach. The dredging was chiefly carried on to the north of Unst, Balta Sound being made the headquarters during the greater portion of the summer. Mr. Peach paid special attention to the sponges, and discovered several new species. Vessel, the 'Osprey.'

1867. Mr. Jeffreys, Mr. Waller, Mr. Dodd, and myself. The bed of the ocean, to the north and west of Shetland, was investigated, and at greater depths than had before been tried. A fortnight was also spent in examining the rich fauna of the deeper parts of St. Magnus Bay. Vessel, Mr. Jeffreys's yacht the 'Osprey.'

1868. Mr. Jeffreys, Mr. Waller, and Major Woodall. Dredging chiefly to the north of Unst and St. Magnus Bay, but the Out Skerries Haaf was also visited. Vessel, the 'Osprey.'

My sincere thanks are especially due to my kind and valued friends Mr. Jeffreys and Mr. Waller, for the assistance they rendered me in all kinds of ways during our dredging operations, and in the preservation of those invertebrata which it is my duty here to notice.

In 1867 Mr. D. Robertson went to Shetland, and, besides dredging and using the towing-net in Bressay Sound, he visited many of the inland lochs and streams, for the purpose of examining the Crustacea which they might contain. I have to thank him for having kindly allowed me to examine the gatherings which he made, and I am thus enabled to add many species to the list of Entomostraca.

In the preparation of the Tables which follow, it must be understood that I have not relied solely on published localities. A large number of the species have been identified by myself from habitats further to the north or to the south than those which have been recorded in print. This will account for the absence of many names from the Tables IV., V., and VII. which might have been expected there.

I.

Comparison of the Total Number of British and of Shetland Species.

The following Table is intended to show—

1. The number of species belonging to the several Classes and Orders, as given in the "List of the British Marine Invertebrate Fauna," published by the British Association in 1861, and which supplies us with a carefully corrected catalogue of the species known seven years ago.

2. The total number of species which have been recorded as British up to the time of publication of this Report. This estimate I have drawn up

with great care. In the second column many species are omitted which, though contained in the first, are not considered by me to be distinct from other described species; consequently the difference between the number of British species now known, and those which had been recognized previously to 1861, is even greater than appears from a comparison of the figures here inserted.

3. The number of species which have been found in the Shetland seas. The inland forms are entirely omitted from these columns. The small area of the Shetland Islands, their isolation, the stunted character of the vegetation, the almost total absence of trees, and the scarcity of ponds or pieces of water other than moorland tarns (which character of water has a restricted fauna peculiarly its own), all tend to limit the numbers of land and fresh-water invertebrata likely to be found in the islands. Our object was the investigation of the marine fauna, and but little attention was paid to that of the land. Those few species, however, which were observed will be found enumerated in the Catalogue, and consist of twenty-two Crustacea (out of one hundred and fifteen known as British) and one Hydrozoon.

			I. British, in 1861.	II. British, in 1868.	III. Shetland.	
ARTHROPODA.	*Crustacea*	Brachyura	41	40	18	
		Anomura	14	15	11	
		Macrura	52	53	26	
		Stomapoda	23	40	23	
		Amphipoda	120	183	110	
		Isopoda	50	66	21	362
		Phyllopoda	2	2	1	
		Cladocera	1	2	2	
		Ostracoda	21	124	87	
		Copepoda	50	87	51	
		Cirripedia	27	25	6	
		Pycnogonoidea	11	25(?)	6	
	Arachnida	Acarina	0	9	2	
MOLLUSCOIDA.		Tunicata	73	104	39	
	Polyzoa	Cheilostomata	110	153	102	
		Cyclostomata	24	25	21	
		Ctenostomata	24	28	10	137
		Pedicellinea	3	3	3	
		Lophopea	0	1	1	
ECHINODERMATA.	....	Holothuroidea	24	20	14	
		Echinoidea	15	16	15	
		Asteroidea	16	18	17	62
		Ophiuroidea	14	16	14	
		Crinoidea	3	4	2	
CŒLENTERATA.	*Actinozoa*	Zoantharia	67	74	21	
		Alcyonaria	11	15	7	34
		Ctenophora	11	11	1	
		Lucernariada	13	14	5	
	Hydrozoa	Thecaphora	72	92	52	
		Athecata	36	72	26	
		"Naked-eyed Medusæ"	69	69	24	104
		Calycophorida	1	1	1	
		Physophorida	3	4	1	
PROTOZOA.	*Porifera*	Calcarea	10	12	5	
		Silicea	101	177	73	83
		Keratosa	10	12	5	
			1122	1612	823	

II.

Comparison of the Shetland Invertebrate Marine Fauna with that of other portions of the British Coast.

No really satisfactory comparison can be made between the number of animals here reported on as inhabiting the Shetland Sea with those found on other portions of our coast. Unfortunately very little attention has hitherto been paid to any, except the larger and more conspicuous forms belonging to these classes. In order, however, that this comparison may be carried out as far as at present practicable, I give the following summaries of the most fully worked up local lists that I am acquainted with.

CRUSTACEA.

	A. Shetland.	B. Northumberland and Durham.	C. Hebrides.	D. Moray Firth.	E. Dublin.	F. Galway.	G. Clyde district, &c.
Brachyura	18	13	16	18	23	30	
Anomura	11	11	6	5	8	8	
Macrura	26	11	18	17	24	22	
Stomapoda	23	9	6	4	4		
Amphipoda	110	53	47	..	22		
Isopoda	21	8	11				
Phyllopoda	1	1	1				
Cladocera	2	2	0				
Ostracoda	87	19	65	30	..	53	67
Copepoda	51	12	22				
Cirripedia	6	9	3				
Pycnogonoidea	6	10	1				
	362	158	196	74	81	113	

B.—Norman, "Report of Deep-Sea Dredging on the Coast of Northumberland and Durham, 1862–64. Crustacea," Nat. Hist. Transac. Northumb. and Durham, vol. i. (1865) p. 12.

C.—Norman, "Report of Committee appointed for the purpose of Exploring the Coasts of the Hebrides by means of the Dredge.—Part II.," British Assoc. Report, 1866, p. 193.

D.—Rev. G. Gordon, "A List of the Crustaceans of the Moray Firth," Zoologist, 1852, p. 3678; and the Ostracoda from G. S. Brady, Trans. Linn. Soc. vol. xxvi. p. 478.

E.—Kinahan, "Report of the Committee appointed to dredge Dublin Bay," Brit. Assoc. Report, 1860, p. 27; and "Report on Crustacea of the Dublin District," Brit. Assoc. Report, 1859, p. 262.

F.—A. G. Melville, "List of Crustacea Podophthalmia of Galway Marine Districts," Nat. Hist. Review, vol. iv. (1857) p. 151; and the Ostracoda added from Mr. G. S. Brady's paper in Trans. Linn. Soc. vol. xxvi.

G.—G. S. Brady, "A Monograph of the Recent British Ostracoda," Trans. Linn. Soc. vol. xxvi. p. 478,—this being the fullest district list given by him.

Tunicata.

The only catalogues for comparison with the thirty-nine Shetland Tunicata are Alder's list of those of the Northumberland and Durham coasts (Catalogue of the Mollusca of the Northumberland and Durham Coasts, p. 101), which includes thirty species, my own very short list of sixteen observed in the Clyde district ("The Mollusca of the Firth of Clyde," Zoologist, 1857, p. 5703), and a third of twenty-one Hebridean species by Mr. Alder (Brit. Assoc. Report, 1866, p. 206).

Polyzoa and Cœlenterata.

	H. Shetland.	I. Northumberland and Durham.	K. Devon and Cornwall.	L. Hebrides.
Polyzoa.				
Cheilostomata	102	59	87	54
Cyclostomata	21	12	14	10
Ctenostomata	10	16	17	2
Pedicellinea	3	3	3	0
Lophopea	1	0	0	0
Actinozoa.				
Zoantharia	21	11	37	4
Alcyonaria	7	4	4	6
Ctenophora	1	0	0	0
Lucernariada	5	2	2	0
Hydrozoa.				
Thecaphora	52	56	58	28
Athecata	26	23	19	4
"Naked-eyed Medusæ"	24	0	0	0
Calycophorida	1	0	0	0
Physophorida	1	0	0	0
	275	186	241	108

I.—Alder, "Catalogue of the Zoophytes of Northumberland and Durham," 1857, and "Supplement" to the same, 1862.

K.—Rev. T. Hincks, "Catalogue of the Zoophytes of South Devon and South Cornwall," 1861–62.

L.—Norman, Brit. Assoc. Report, 1866, p. 199.

Echinodermata.

	M. Shetland.	N. Northumberland and Durham.	O. Hebrides.	P. Orkney.	Q. Moray Firth.	R. Dublin.
Holothuroidea	14	9	9	3	1	4
Echinoidea	15	10	6	7	6	5
Asteroidea	17	8	8	10	11	8
Ophiuroidea	14	10	9	7	7	7
Crinoidea	2	1	2	1	1	1
	62	38	34	28	26	25

N.—G. Hodge, "Report of Deep-Sea Dredging on the Coasts of Northumberland and Durham, 1862–64.—Echinodermata," Nat. Hist. Trans. Northumb. and Durham, vol. i. p. 42.

O.—Norman, Brit. Assoc. Report, 1866, p. 198.

P.—Dr. W. B. Baikie, "Catalogue of the Echinodermata of Orkney," Zoologist, 1853, p. 3811. (Several species are included in Dr. Balfour Baikie's list for which no Orkney habitat is given; these are here omitted.)

Q.—Rev. G. Gordon, "List of the Echinodermata hitherto met with in the Moray Firth," Zoologist, 1853, p. 3781.

R.—Kinahan, Brit. Assoc. Report, 1860, p. 31.

Porifera.

The only local List of Sponges is one recently published by Mr. E. Parfitt, "On the Marine and Freshwater Sponges of Devonshire" (Trans. Devonshire Association for the Advancement of Science, Literature, and Art, 1868); it includes forty-nine marine species, while the Shetland species observed by us are eighty-three. Only eighteen of these species are as yet known to be common to these two extremities of our islands.

III.

Species added to the British Fauna during the recent Dredging.

The new species which have during the past six years been discovered in Shetland have from time to time been published through various channels, a large proportion of them having been placed in the hands of those naturalists who were engaged in bringing out works on the several branches of marine zoology. The following list of 156 species is therefore given here in order to show at a glance the additions to our fauna which have directly resulted from the investigations of the Dredging Committee.

Portunus tuberculatus, *Roux.*
Pagurus tricarinatus, *Norman.*
Crangon serratus, *Norman.*
Sabinæa septemcarinata (*Sabine*).
Lophogaster typicus, *M. Sars.*
Thysanopoda Norvegica, *M. Sars.*
Mysis inermis, *Rathke.*
—— ornata, *G. O. Sars.*
Mysidopsis hispida, *Norman.*
Gastrosaccus sanctus (*Van Beneden*).
Nematopus serratus, *G. O. Sars.*
Nannasticus binoculoides, *Bate.*
Diastylis echinata, *Bate.*
—— bispinosa (*Stimpson*).
—— lævis, *Norman.*
—— spinosa, *Norman.*
Cumella agilis, *Norman.*
Probolium serratipes, *Norman.*
Anonyx nanus, *Kröyer.*
—— nanoides, *Lilljeborg.*
—— ampulla (*Phipps*).
—— tumidus, *Kröyer.*
Stegocephalus ampulla (*Phipps*).
Opis leptochela, *Bate & Westw.*
Pontoporeia affinis, *Lindström.*
Ampelisca lævigata, *Lilljeborg.*
Œdiceros parvimanus, *B. & W.*
—— æquicornis, *Norman.*
Kroyera altamarina, *B. & W.*
Syrrhoë hamatipes, *Norman.*
Lilljeborgia Shetlandica, *B. & W.*
Dexamine Vedlomensis, *B. & W.*
Atylus macer, *Norman.*
Calliopius Fingalli, *B. & W.*
Megamphopus cornutus, *Norman.*
Protomedeia pectinata, *Norman.*
Heiscladus longicaudatus, *B. & W.*
Amphithoë albomaculata, *Kröyer.*
Siphonœcetes typicus, *Kröyer.*
Cyrtophium armatum, *Norman.*
Corophium tenuicorne, *Norman.*
Hyperia oblivia, *Kröyer* (not *B. & W.*).
Metoëcus medusarum, *Kröyer.*
Phryxus longibranchiatus, *B. & W.*
Cirolana truncata, *Norman.*
Pontocypris hispida, *G. O. Sars.*
Cythere dubia, *G. S. Brady.*
—— costata, *Brady.*
—— mucronata (*G. O. Sars*).
—— abyssicola (*G. O. Sars*).
—— crenulata (*G. O. Sars*).
—— leioderma, *Norman.*
Cytherura concentrica, *C. B. & R.* (MS.).
—— flavescens, *Brady.*
—— quadrata, *Norman.*
—— navicula, *Norman.*

Sarsiella capsula, *Norman.*
Cytheropteron alatum, *G. O. Sars.*
Bythocythere tenuissima, *Norman.*
Cypridina Norvegica, *Baird.*
Conchoëcia obtusata, *G. O. Sars.*
Polycope dentata, *Brady.*
Cyclops nigricauda, *Norman.*
—— pallidus, *Norman.*
Amymone falcata, *Norman.*
Cleta forcipata, *Claus.*
Tigriopus Lilljeborgii, *Norman.*
Thalestris Clausii, *Norman.*
Porcellidium subrotundum, *Norman.*
Aspidiscus fasciatus, *Norman.*
Ascomyzon echinicola, *Norman.*
Lichomolgus forficula, *Thorell.*
Entorocola eruca, *Norman.*
Notodelphys cærulea, *Thorell.*
—— prasina, *Thorell.*
Doropygus auritus, *Thorell.*
Botachus cylindratus, *Thorell.*
Notopterophorus papilio, *Hesse.*
Nogagus Lütkeni, *Norman.*
Brachiella rostrata, *Kröyer.*
Nymphon Strömii, *Kröyer.*
Ascidia obliqua, *Alder.*
—— rudis, *Alder.*
—— plebeia, *Alder.*
Polyclinum succineum, *Alder.*
Menipea Jeffreysii, *Norman.*
Hippothoa expansa, *Norman.*
Membranipora sacculata, *Norman.*
Lepralia cruenta, *Norman.*
—— laqueata, *Norman.*
—— abyssicola, *Norman.*
—— polita, *Norman.*
—— microstoma, *Norman.*
—— minuta, *Norman.*
—— tubulosa, *Norman.*
Cellepora lepralioides, *Norman.*
—— pygmæa, *Norman.*
Cellepora attenuata, *Alder.*
Palmicellaria elegans, *Alder.*
Hemeschara struma, *Norman.*
Eschara lorea, *Alder.*
Hornera borealis, *Busk.*
—— violacea, *M. Sars.*
Alecto diastoporides, *Norman.*
Rhabdopleura Normani, *Allman.*
Thyone elegans, *Norman.*
Spatangus meridionalis, *Risso.*
Echinus pictus, *Norman.*
Asterias Mülleri, *M. Sars.*
Astropecten acicularis, *Norman.*
Archaster Parelii (*Düb. & Kor.*).
Ophiura Sarsii, *Lütken.*
Ophiopeltis securigera, *Düb. & Kor.*
Zoanthus anguicoma, *Norman.*
Cuspidella humilis, *Hincks.*
—— grandis, *Hincks.*
Obelia plicata, *Hincks.*
Gonothyræa hyalina, *Hincks.*
Clava diffusa, *Allman.*
Tubiclava cornucopiæ, *Norman.*
Coryne nutans, *Allman.*
—— vermicularis, *Hincks.*
Eudendrium annulatum, *Norman.*
—— vaginatum, *Allman.*
Perigonimus minutus, *Allman.*
Tubularia bellis, *Allman.*
—— attenuata, *Allman.*
Physophora (? borealis, *Sars*).
Normania crassa, *Bowerbank.*
Ecionemia compressa, *Bow.*
Polymastia bulbosa, *Bow.*
—— radiosa, *Bow.*
Tethea spinularia, *Bow.*
Dictyocylindrus virgultosus, *Bow.*
Phakellia robusta, *Bow.*
Microciona ambigua, *Bow.*
—— simplicissima, *Bow.*
Hymeraphia coronula, *Bow.*
Hymedesmia radiata, *Bow.*
—— occulta, *Bow.*
Hymeniacidon reticulatus, *Bow.*
—— perarmatus, *Bow.*
—— membrana, *Bow.*
—— paupertas, *Bow.*
Halichondria forcipis, *Bow.*
—— simplex, *Bow.*
—— scandens, *Bow.*
—— mutulus, *Bow.*
—— inornata, *Bow.*
—— falcula, *Bow.*
Isodictya jugosa, *Bow.*
—— laciniosa, *Bow.*
Raphioderma coacervata, *Bow.*
Oceanapia Jeffreysii (*Bow.*).
Desmacidon Peachii, *Bow.*
—— constrictus, *Bow.*

IV.

Scandinavian and Arctic Species which have not been observed further south than Shetland, for the most part inhabitants of very deep water.

Sabinæa septemcarinata (*Sabine*).
Lophogaster typicus, *M. Sars.*
Nematopus serratus, *G. O. Sars.*
Anonyx nanoides, *Lilljeborg.*
—— ampulla (*Phipps*).
Stegocephalus ampulla (*Phipps*).
Pontoporeia affinis, *Lindström.*
Amphithoë albomaculata, *Kröyer.*
Siphonœcetes typicus, *Kröyer.*
Metoëcus medusarum, *Kröyer.*

Pontocypris hispida, *G. O. Sars.*
Macrocypris minna (*Baird*).
Cythere costata, *Brady.*
—— mucronata (*G. O. Sars*).
—— abyssicola (*G. O. Sars*).
—— crenulata (*G. O. Sars*).
Cytheropteron alatum, *G. O. Sars.*
Cypridina Norvegica, *Baird.*
Conchoëcia obtusata, *G. O. Sars.*
Bicellaria Alderi, *Busk.*
Membranipora cornigera, *Busk.*
—— rhynchota, *Busk.*
—— vulnerata, *Busk.*
Alysidota Alderi, *Busk.*
Lepralia bella, *Busk.*
—— abyssicola, *Norman.*
—— microstoma, *Norman.*
Lepralia ringens, *Busk.*
—— monodon, *Busk.*
Celleporella lepralioides, *Norman.*
Tessarodoma gracile (*M. Sars*).
Eschara lævis (*Fleming*).
Hornera violacea, *Sars.*
Defrancia truncata (*Jameson*).
Echinus Norvegicus, *Düb. & Kor.*
Cidaris papillata, *Leske.*
Archaster Parelii (*Düb. & Kor.*).
Ophiura Sarsii, *Lütken.*
Ophiopeltis securigera, *Düb. & Kor.*
Astrophyton Linckii, *Müll. & Trosch.*
Antedon Sarsii (*Düb. & Kor.*).
Ulocyathus arcticus, *M. Sars.*
Lophohelia prolifera (*Linn.*).
Primnoa lepadifera (*Linn.*).

V.

Species which have as yet only been found in the Shetland Seas.*

Pagurus tricarinatus, *Norman.*
Probolium serratipes, *Norman.*
Œdiceros æquicornis, *Norman.*
Syrrhoë hamatipes, *Norman.*
Atylus macer, *Norman.*
Megamphopus cornutus, *Norman.*
Protomedeia pectinata, *Norman.*
Cyrtophium armatum, *Norman.*
Corophium tenuicorne, *Norman.*
Cirolana truncata, *Norman.*
Cythere dubia, *G. S. Brady.*
—— leioderma, *Norman.*
Cytheridea Zetlandica, *Brady.*
Cytherura navicula, *Norman.*
Sarsiella capsula, *Norman.*
Cytheropteron rectum, *Brady.*
Bythocythere tenuissima, *Norman.*
Polycope dentata, *Brady.*
Amymone falcata, *Norman.*
Porcellidium subrotundum, *Norman.*
Aspidiscus fasciatus, *Norman.*
Entorocola eruca, *Norman.*
Ascomyzon echinicola, *Norman.*
Nogagus Lütkeni, *Norman.*
Polyclinum succineum, *Alder.*
Hippothoa expansa, *Norman.*
? Lepralia umbonata, *Busk.*
Celleporella pygmæa, *Norman.*
Cellepora attenuata, *Alder.*
Eschara lorea, *Alder.*
Hemeschara struma, *Norman.*
? Pustulipora orchadensis, *Busk.*
Rhabdopleura Normani, *Allman.*
Thyone elegans, *Norman.*
Cucumaria fucicola (*Forbes & Goodsir*).
Psolinus brevis (*Forbes & Goodsir*).
Actinia intestinalis, *Fleming.*
—— vermicularis, *Forbes.*
Zoanthus anguicoma, *Norman.*
Sidisia Barleeii, *Gray.*
Paracyathus Thulensis, *Gosse.*
Cuspidella humilis, *Hincks.*
—— grandis, *Hincks.*
Obelia plicata, *Hincks.*
Gonothyræa hyalina, *Hincks.*
Clava diffusa, *Allman.*
Coryne vermicularis, *Hincks.*
—— nutans, *Allman.*
Eudendrium annulatum, *Norman.*
—— vaginatum, *Allman.*
Perigonimus minutus, *Allman.*
Tubularia bellis, *Allman.*
—— attenuata, *Allman.*
Thaumantias maculata, *Forbes.*
—— globosa, *Forbes.*
—— melanops, *Forbes.*
—— lineata, *Forbes.*
Trachynema rosea (*Forbes*).
Pandea globulosa (*Forbes*).
Tiara turrita (*Forbes*).
Lizzia blondina, *Forbes.*
Margelis nigritella (*Forbes*).
Steenstrupia rubra, *Forbes.*
Ectopleura pulchella (*Forbes*).
Geodia Zetlandica (*Johnston*).
Ecionemia compressa, *Bow.*
Quasillina brevis (*Bow.*).
Polymastia bulbosa, *Bow.*
Tethea spinularia, *Bow.*
Halicnemia patera, *Bow.*
Dictyocylindrus virgultosus, *Bow.*
Phakellia robusta, *Bow.*

* Of course it will be understood that all that is meant by this expression is that we as yet know nothing whatever of the distribution of the species contained in this list.

Microciona lævis, *Bow.*
—— ambigua, *Bow.*
—— simplicissima, *Bow.*
Hymeraphia vermiculata, *Bow.*
—— coronula, *Bow.*
Hymedesmia radiata, *Bow.*
—— Zetlandica, *Bow.*
—— occulta, *Bow.*
Hymeniacidon reticulatus, *Bow.*
—— perarmatus, *Bow.*
—— membrana, *Bow.*
—— paupertas, *Bow.*
Halichondria forcipis, *Bow.*
—— simplex, *Bow.*
—— scandens, *Bow.*
? Halichondria Batei, *Bow.*
—— albula, *Bow.*
—— inornata, *Bow.*
—— mutulus, *Bow.*
—— falcula, *Bow.*
Isodictya varians, *Bow.*
—— jugosa, *Bow.*
—— Barleei, *Bow.*
—— fimbriata, *Bow.*
Raphioderma coacervata, *Bow.*
Oceanapia Jeffreysii (*Bow.*).
Desmacidon Peachii, *Bow.*
—— constrictus, *Bow.*
Diplodemia vesicula, *Bow.*
Verongia Zetlandica, *Bow.*

VI.

Mediterranean Species which occur in Shetland, but have not been found at intermediate localities.

Two large and conspicuous animals, *Portunus tuberculatus*, Roux, and *Spatangus meridionalis*, Risso, have been found abundantly in these dredgings at a depth from eighty to one hundred and forty fathoms. They are well known in the south of Europe, but were supposed up to the time of their discovery in Shetland not to occur north of the Mediterranean. It is not unlikely that *Pagurus tricarinatus*, Norman, will also prove to be a deep-water Mediterranean form. All deep-water dredging seems to establish this fact more clearly, that deep-water species have a much more extended geographical range than shallow-water and littoral forms. These Mediterranean species must have made their way northwards in the abyss of the sea round the western coast of Ireland, in which locality they will doubtless at some future day be found. The classes on which it is my lot to report have been so much neglected, and our knowledge therefore of their distribution is at present so extremely limited, that it is at present impossible to draw any satisfactory conclusions as to their range; but I feel satisfied that when hereafter fuller and more accurate investigation shall have been carried on both in the Mediterranean and our own coasts, not only will the number of species common to the two extremities of Europe be found to be much greater than is now generally supposed, but also that a very large proportion of such species will prove to be forms which will be met with in the depths of the Mediterranean and of the seas to the west and north of our country, but which will be found to be absent from the channels which intersect and the shallower water which immediately surrounds our islands. Meanwhile the occurrence of *Portunus tuberculatus* and *Spatangus meridionalis* is of excessive interest, as such fine and handsome species could not have been well overlooked, or have failed to attract attention in any portion of the sea which has been at all efficiently dredged*.

The contents of the three Tables (IV., V., and VI.) added together give the

* The following northern Mollusca have been identified by Mr. Jeffreys from the Mediterranean, but are not known elsewhere south of the north of Scotland or Shetland Sea:—*Pecten aratus, P. vitreus, Lima Sarsii, Leda pygmæa, Scissurella crispata, Aclis Walleri, Cerithium metula*, &c.; the occurrence also of the following in the Mediterranean is very unexpected:—*Terebratula caput-serpentis, Crania anomala, Pecten septemradiatus, Axinus Croulinensis, Chiton Hanleyi, Propilidium ancyloides, Rissoa abyssicola, Scalaria Trevelyana, Odostomia Scillæ, Bulla utriculus*, &c.

number of Shetland species which are as yet unknown off other parts of the British coast as one hundred and forty-eight.

VII.

Southern and other forms which are not as yet known to the North of Shetland.

Stenorhynchus longirostris (*Fab.*).
Inachus leptochirus, *Leach.*
Portunus holsatus (*Fab.*).
—— tuberculatus, *Roux.*
Porcellana platycheles (*Pennant*).
Pagurus Hyndmanni, *Thompson.*
—— ferrugineus, *Norman.*
Galathea dispersa, *Bate.*
Crangon trispinosus, *Hailstone.*
Nika edulis, *Risso.*
Hippolyte cultellata, *Norman.*
Mysidopsis hispida, *Norman.*
Nannasticus binoculoides, *Bate.*
Diastylis lævis, *Norman.*
—— lamellata, *Norman.*
—— spinosa, *Norman.*
Cumella agilis, *Norman.*
Iphinoë serrata, *Norman.*
—— gracilis, *Bate.*
Cuma scorpioides (*Montagu*).
Probolium monoculoides (*Montagu*).
—— marinum (*Bate*).
—— pollexianum (*Bate*).
Lysianassa Audouiniana, *Bate.*
—— longicornis, *Lucas.*
Anonyx longicornis, *Bate.*
—— melanophthalmus, *Norman.*
Callisoma crenata, *Bate.*
Œdiceros parvimanus, *B. & W.*
Monoculodes Stimpsoni, *Bate.*
Kroyera altamarina, *B. & W.*
Urothoë, species.
Lilljeborgia Shetlandica, *B. & W.*
Helleria coalita, *Norman.*
Dexamine Vedlomensis, *B. & W.*
Atylus gibbosus, *Bate.*
—— bispinosus, *Bate.*
Pherusa fucicola, *Leach.*
Calliopius Ossiani (*Bate*) ?.
Eusirus Helvetiæ, *Bate.*
Gossea microdeutopa, *Bate.*
Microdeuteropus versiculatus, *Bate.*
—— Websteri, *Bate.*
Protomedeia hirsutimana, *Bate.*
Bathyporeia Robertsoni, *Bate.*
Mæra brevicaudata (*Bate*).
Heiscladus longicaudatus, *B. & W.*
Sunamphithoë hamulus, *Bate.*
Sunamphithoë conformata, *Bate.*
Podocerus variegatus, *Leach*?.
—— falcatus (*Montagu*).
—— pelagicus (*Leach*).
Cerapus abditus, *Templeton.*
—— difformis (*M.-Edwards*).
Næenia rimapalmata, *Bate.*
—— excavata, *Bate.*
Unciola planipes, *Norman.*
Corophium longicorne (*Fabr.*).
Dulichia porrecta, *Bate.*
Phryxus Galatheæ (*Hesse*).
Cirolana spinipes, *B. & W.*
Eurydice pulchra, *Leach.*
Arcturus gracilis, *Goodsir.*
Pontocypris acupunctata, *G. S. Brady.*
Bairdia inflata (*Norman*).
—— complanata, *Brady.*
Cythere quadridentata, *Baird.*
—— emaciata, *Brady.*
—— antiquata (*Baird*).
—— acerosa, *Brady.*
Paradoxostoma Normani, *Brady.*
—— ensiforme, *Brady.*
Cylindroleberis Mariæ (*Baird*).
Copepoda, very many.
Ascidia rudis, *Alder.*
—— sordida, *A. & H.*
—— depressa, *A. & H.*
—— plebeia, *Alder.*
—— elliptica, *A. & H.*
Molgula citrina, *A. & H.*
Salicornaria Johnsoni, *Busk.*
Membranipora imbellis, *Hincks.*
—— Rosselii (*Audouin*).
Lepralia Brongniartii (*Aud.*).
—— Hyndmanni, *Johnst.*
—— Woodiana, *Busk.*
—— discoidea, *Busk.*
—— innominata, *Couch.*
—— bispinosa, *Johnst.*
—— collaris, *Norman.*
—— pertusa (*Esper*).
—— labrosa, *Busk.*
—— simplex, *Johnst.*
—— tubulosa, *Norman.*
Buskia nitens, *Alder.*

So little is known of the Scandinavian and Arctic Cœlenterata and Porifera that I have omitted these altogether from this list.

VIII.

Species peculiarly characteristic of the Fauna of the Outer Haaf.

The following list gives the species which impart a peculiar character to the fauna of the deep sea of Shetland, known as the "Outer Haaf," in a depth of 80–170 fathoms. The Molluscan inhabitants of this region are highly interesting, but it is not within my province here to speak of them. Crustacea are few in numbers, *Portunus tuberculatus, Munida,* two or three species of *Crangon, Pandalus brevirostris, Cumacea, Ampelisca,* and *Epimeria tricristata* being the most abundant. Echinodermata are abundant, and certain species sometimes in the most extraordinary profusion. Polyzoa and Sponges are very abundant, but of Cœlenterata there are but few species; those species which do occur belong, for the most part, to the Zoantharia. *Caryophyllia Smithii* var. *borealis* is found inhabiting these depths in marvellous abundance; *Zoanthus anguicoma* is common, creeping over Sponges from the greatest depths, and an occasional *Bulocera eques* or *Tuediæ,* or a noble *Ulocyathus arcticus* presents itself to our admiring gaze. Very few Tunicata occur below seventy fathoms.

The names which follow are of the most abundant or, at any rate, more conspicuous species; the list might, had I so wished, have been greatly extended.

Hyas coarctatus, *Leach.*
Portunus pusillus, *Leach.*
—— tuberculatus, *Roux.*
Ebalia tuberosa (*Penn.*).
Atelecyclus septemdentatus (*Montagu*).
Pagurus pubescens, *Kröyer.*
Munida Bamffia (*Penn.*).
Crangon Allmani, *Kinahan.*
—— nanus *Kröyer.*
—— spinosus, *Leach.*
—— serratus, *Norman.*
Sabinæa septemcarinata (*Sabine*).
Hippolyte securifrons, *Norman.*
—— cultellata, *Norman.*
Pandalus annulicornis, *Leach.*
—— brevirostris, *Rathke.*
Lophogaster typicus, *M. Sars.*
Cumacea, species.
Anonyx tumidus, *Kröyer.*
Ampelisca, species.
Kröyera altamarina, *B. & W.*
Odius carinatus (*Bate*).
Epimeria tricristata, *Costa.*
Amphithoë albomaculata, *Kröyer.*
Siphonœcetes typicus, *Kröyer.*
Nænia rimapalmata, *Bate.*
Pontocypris mytiloides (*Norman*).
Bairdia complanata, *Brady.*
Macrocypris minna, *Baird.*
Cythere concinna, *Jones.*
—— angulata (*G. O. Sars*).
—— dubia, *Brady.*
—— costata, *Brady.*
—— mucronata (*G. O. Sars*).
—— antiquata (*Baird*).
Cythere Jonesii (*Baird*).
—— abyssicola (*Sars*).
—— crenulata (*Sars*).
—— leioderma, *Norman.*
Cytheridea papillosa, *Bosquet.*
—— punctillata, *Brady.*
—— subflavescens, *Brady.*
—— Sorbyana, *Jones.*
Eucythere declivis (*Norman*).
Sarsiella capsula, *Norman.*
Cytheropteron nodosum, *Brady.*
—— latissimum (*Norman*).
—— alatum, *G. O. Sars.*
Bythocythere turgida, *G. O. Sars.*
Cypridina Norvegica, *Baird.*
Conchoëcia obtusata, *G. O. Sars.*
Polycope dentata, *Brady.*
—— orbicularis, *G. O. Sars.*
Verruca Strömia (*Müller*).
Alcippe lampas, *Hancock.*
Nymphon Strömii, *Kröyer.*
Scrupocellaria inermis, *Norman.*
Bicellaria Alderi, *Busk.*
Flustra Barleei, *Busk.*
Hippothoa catenularia, *Jameson.*
—— expansa, *Norman.*
Membranipora sacculata, *Norman.*
—— Dumerillii (*Audouin*).
—— cornigera, *Busk.*
—— rhynchota, *Busk.*
—— Rosselii (*Audouin*).
—— vulnerata, *Busk.*
Lepralia crystallina, *Norman.*
—— auriculata, *Hass.*
—— bella, *Busk.*

Lepralia sinuosa, *Busk.*
—— cruenta, *Norman.*
—— ansata, *Johnst.*
—— Woodiana, *Busk.*
—— ventricosa, *Hass.*
—— laqueata, *Norman.*
—— abyssicola, *Norman.*
—— polita, *Norman.*
—— microstoma, *Norman.*
—— ringens, *Busk.*
—— monodon, *Busk.*
Alysidota Alderi, *Busk.*
Celleporella lepralioides, *Norman.*
—— pygmæa, *Norman.*
Cellepora dichotoma, *Hincks.*
—— ramulosa, *Linn.*
—— attenuata, *Alder.*
—— cervicornis, *Ellis & Sol.*
Palmicellaria elegans, *Alder.*
Tessarodoma gracile (*Sars*).
Hemeschara struma, *Norman.*
Eschara lævis (*Fleming*).
—— lorea, *Alder.*
—— Skenei (*Ellis & Sol.*).
Retipora Beaniana, *King.*
Crisia eburnea, var. producta, *Smitt.*
Hornera borealis, *Busk.*
—— violacea, *Sars.*
Idmonea Atlantica, *Forbes.*
Tubulipora lobularis, *Hassall.*
Alecto major, *Johnst.*
—— compacta, *Norman.*
—— diastoporides, *Norman.*
Defrancia truncata (*Jameson*).
Synapta digitata (*Mont.*), purple variety.
Thyone raphanus, *Düb. & Kor.*
Thyonidium hyalinum (*Forbes*).
Cucumaria Hyndmanni (*Thompson*).
Spatangus purpureus (*Müller*).
—— meridionalis, *Risso.*
Echinocardium ovatum (*Leske*).
Brissopsis lyrifera (*Forbes*).
Toxopneustes pictus, *Norman.*
Echinus Norvegicus, *Düb. & Kor.*
—— Flemingii, *Bell.*
—— esculentus, var. tenuispina, *Norman.*
Cidaris papillata, *Leske.*
Cribrella sanguinolenta, var. abyssicola, *Norman.*
Goniaster Phrygianus (*Parelius*).
Porania pulvillus (*Müller*).
Archaster Parelii (*Düb. & Koren*).
Astropecten acicularis, *Norman.*
Ophiura affinis, *Lütken.*
—— Sarsii, *Lütken.*
Amphiura Ballii (*Thompson*).
Antedon Sarsii (*Düb. & Kor.*).
Bulocera eques, *Gosse.*
—— Tuediæ (*Johnst.*).
Zoanthus anguicoma, *Norman.*
Caryophyllea Smithii, var. borealis, *Fleming.*
Ulocyathus arcticus, *Sars.*
Diphasia alata, *Hincks.*
Tubiclava cornucopiæ, *Norman.*
Normania crassa, *Bowerbank.*
Ecionemia compressa, *Bow.*
Quasillina brevis (*Bow.*).
Polymastia spinula, *Bow.*
Tethea cranium (*Müller*).
Halicnemia patera, *Bow.*
Dictyocylindrus rugosus, *Bow.*
Phakellia robusta, *Bow.*
—— ventilabrum (*Linn.*).
Microciona, species.
Hymeraphia, species.
Hymedesmia, species.
Hymeniacidon lingua, *Bow.*
—— ficus (*Esper*).
Halichondria forcipis, *Bow.*
Isodictya infundibuliformis (*Linn.*).
—— laciniosa, *Bow.*
—— fimbriata, *Bow.*
Raphioderma coacervata, *Bow.*
Oceanapia Jeffreysii, *Bow.*
Verongia Zetlandica, *Bow.*

IX.

Species especially characteristic of the Fauna of the Southern portion of the British Isles, which are wholly absent from the Shetland Seas.

From this list are excluded most of such southern forms as are rare and very local in their distribution.

Achæus Cranchii, *Leach.*
Pisa, genus.
Maia squinado (*Herbst*).
Xantho floridus (*Montagu*).
—— tuberculatus, *Bell.*
Pilumnus hirtellus (*Linn.*).
Perimela denticulata (*Mont.*).
Portumnus latipes (*Penn.*).
Portunus marmoreus, *Leach.*
Portunus corrugatus (*Pennant*).
—— longipes, *Risso.*
—— arcuatus, *Leach.*
Polybius Henslowii, *Leach.*
Pinnotheres pisum (*Penn.*).
—— veterum, *Bosc.*
Nautilograpsus minutus (*Linn.*) (= Planes Linnæana, *Bell*).
Gonoplax angulata (*Fabr.*).

Corystes cassivelaunus (*Pennant*).
Thia polita, *Leach.*
Dromia vulgaris, *M.-Edw.*
Diogenes varians (*Costa*) (=Pagurus Dillwynii, *Bate*).
Callianassa subterranea (*Mont.*).
Axius stirynchus, *Leach.*
Gebia, genus.
Palinurus vulgaris, *Latr.*
Crangon sculptus, *Bell.*
Alpheus, genus.
Typton spongicola, *Costa.*
Athanas nitescens, *Leach.*
Hippolyte viridis, *Otto.*
Palæmon serratus (*Penn.*).
—— Leachii, *Bell.*
—— varians, *Leach.*
Pasiphæa sivado, *Risso.*
Mysis Griffithsiæ, *Bell.*
Squilla, genus.
Orchestia Mediterranea, *Costa.*
—— Deshayesii, *Aud.*
Nicea Lubbockiana, *Bate.*
Isæa Montagui, *M.-Edw.*
Gammarella brevicaudata, *M.-Edw.*
Mæra grossimana (*Mont.*).
—— semiserrata (*Bate*).
—— Batei, *Norman.*
Dryope, genus.
Caprella acutifrons, *Latr.*
Paranthura Costana, *Bate.*
Bopyrus squillarum, *Latr.*
Gyge branchialis, *Cor. & Panc.* (=G. Galatheæ, *B. & W.*).
Ione thoracica (*Montagu*).
Rocinela Danmoniensis, *Leach.*
Conilera cylindracea (*Mont.*).
Idotea linearis (*Penn.*).
—— acuminata (*Leach*).
—— appendiculata (*Risso*).
Dinamene, genus.
Campecopea, genus.
Næsa bidentata (*Adams*).
Balanus spongicola, *Brown.*
—— perforatus, *Bruguière.*
Acasta spongites, *Poli.*
Pyrgoma anglicum (*Leach*).
Scrupocellaria scrupea, *Busk.*
Notamia bursaria (*Linn.*).
Caberea Boryi (*Aud.*).
Flustra papyracea, *Ellis.*
Lepralia violacea, *Johnst.*
—— Gattyæ, *Lands.*
—— variolosa, *Johnst.*
—— figularis, *Johnst.*
—— Cecelii (*Aud.*).
—— divisa, *Norman.*
—— vulgaris (*Moll.*).
—— venusta, *Norman.*
—— armata, *Hincks.*
Cellepora edax, *Busk.*
Eschara foliacea, *Ellis & Sol.*
—— sanguinea, *Norman.*
Amathia lendigera (*Linn.*).
Mimosella gracilis, *Hincks.*
Holothuria nigra, *Couch* (?=H. tubulosa, *Linn.*).
Echinus lividus, *Lamk.*
Asterina gibbosa (*Penn.*).
Zoantharia, numerous.
Sphenotrochus M'Andrewanus, *M.-Edw.*
Balanophyllea regia, *Gosse.*
Gorgonia verrucosa, *Linn.*
Sertularia nigra, *Pallas.*
Plumularia cristata, *Lamk.*
—— tubulifera, *Hincks.*
?—— fusca, *Johnst.*
—— pennatula (*Ellis & Sol.*).
—— obliqua (*Saunders*).
Leuconia nivea (*Johnst.*).
Grantia tessellata, *Bow.*
Leucosolenia contorta, *Bow.*
Tethea Collingsii, *Bow.*
—— Schmidtii, *Bow.*
Halyphysema Tumanowiczii, *Bow.*
Ciocalypta penicillus, *Bow.*
Dictyocylindrus fascicularis, *Bow.*
Hymeniacidon Brettii, *Bow.*
—— albescens, *Bow.*
—— caruncula, *Bow.*
—— sanguinea (*Grant*).
—— aurea (*Mont.*).
Halichondria corrugata, *Bow.*
—— nigricans, *Bow.*
Isodictya rosea, *Bow.*
—— fistulosa, *Bow.*
—— mammeata, *Bow.*
—— simulans, *Johnst.*
Desmacidon ægagrophila (*Johnst.*).
Chalina Montagui (*Johnst.*).
—— limbata (*Montagu*).
—— seriata (*Johnst.*).

Enumeration of Species.

Class CRUSTACEA.

There is no text-book which embraces all the orders of Crustacea, and which can be followed in this class. Even for the separate orders few guides can be found that are at all up to the standard of the present state of our knowledge of the British forms. For the Podophthalmia I have in

the main followed the arrangement of Bell's 'British Stalk-eyed Crustacea;' but the law of priority in nomenclature is not sufficiently attended to in that work, and it is necessary therefore, in numerous instances, to substitute the earlier names under which the species was described; and moreover so greatly has the study of even these larger and better known Crustacea advanced during the last few years that, of the seventy-eight species of this subclass here recorded, no less than thirty-one are undescribed in the work referred to. In the Amphipoda and Isopoda I have followed the general arrangement of the recently published work upon 'The British Sessile-eyed Crustacea,' by Messrs. Bate and Westwood. In the Ostracoda, two admirable guides exist in Herr G. O. Sars's 'Oversigt af Norges marine Ostracoder, 1865,' and Mr. G. S. Brady's "Monograph of the recent British Ostracoda" (Trans. Linn. Soc. vol. xxvi. 1868). In the Copepoda, I have derived great assistance from Dr. Claus's 'Die frei-lebenden Copepoden,' and from the smaller memoirs by the same author. Descriptions of most of the remaining species in the following catalogue must be sought in the various papers, monographs, and works which will be found referred to in the text.

Order BRACHYURA.

Stenorhynchus rostratus (Linn.) (*S. phalangium*, Penn.). 5–70 fathoms, hard ground, frequent.

—— *longirostris* (Fabr.) (*S. tenuirostris*, Leach). A few specimens off Balta &c.

Inachus Dorsettensis (Penn.). Very rare. One specimen in 1864, and a few more in 1867.

—— *dorhynchus*, Leach. Bressay Sound, off Balta, &c.

—— *leptochirus*, Leach. Not rare in deep water.

Hyas araneus (Linn.). Large in laminarian zone.

—— *coarctatus*, Leach. The most abundant of the higher Crustacea in the Shetland seas.

Eurynome aspera (Pennant). Rare.

Xantho rivulosus (Risso). One young specimen dredged (1867) near the Island of Balta. Small examples have been taken in Sweden by Lovén and Göes.

Cancer pagurus, Linn.

Carcinus mœnas (Linn.). Remarkably large.

Portunus depurator (Linn.). Very rare, only two specimens.

—— *holsatus*, Fabr. Frequent.

—— *pusillus*, Leach. Frequent.

—— *tuberculatus*, Roux, Crust. de la Méditerranée, pl. xxxii. figs. 1–5, = *Portunus pustulatus*, Norman, Brit. Assoc. Rept. 1861 (1862), p. 151. This fine addition to our fauna was first procured by me in 1861, and has been taken every year since. It is the most abundant of the genus in the Shetland seas, living in 80–120 fathoms. The fact of this fine Mediterranean species occurring in the deep Shetland seas, in company with many other southern forms, which are not known in intermediate localities between the Mediterranean and the most northern portion of the seas, is highly interesting. *Portunus tuberculatus* is distinguished by its tubercular, pustulose carapace, by the acuteness of the latero-anterior teeth, and the great size of the posterior tooth, which is double the length of the preceding ones, and by the last legs having the swimming-blade furnished with a raised median line.

Ebalia tuberosa (Pennant) (*E. Pennantii*, Leach). Abundant.
—— *tumefacta* (Mont.) (*E. Bryerii*, Leach). A single specimen, 1864. Curiously I have not found *E. Cranchii* in Shetland, though it seems widely distributed on the Scotch coast.
Atelecyclus septemdentatus (Montagu), = *A. heterodon*, Leach. Common.

Order ANOMURA.

Lithodes maia (Linn.).
Porcellana platycheles (Pennant). Tide-marks, Out Skerries and Lerwick.
—— *longicornis* (Linn.). Common ; a pretty variety with white carapace in the neighbourhood of the Out Skerries.
Pagurus Bernhardus (Linn.).
—— *Prideauxii*, Leach. Common, always with *Adamsia*.
—— *cuanensis*, Thompson. Rare, 15 fathoms. Vidlom Voe, 1861 ; also 5–7 miles off Balta, 40–50 fathoms, 1867.
—— *pubescens*, Kröyer (*P. Thompsoni*, Bell). Common. A variety occurs in which the hands are entirely free from the hairs which ordinarily clothe them.
—— *Hyndmanni*, Thompson. 3–12 fathoms ; Bressay and Balta Sounds ; hard ground.
—— *levis*, Thompson. Common on the Haddock (soft) grounds.
—— *ferrugineus*, Norman, Ann. Nat. Hist. Oct. 1861, pl. xiii. figs. 1–3. Two specimens taken in Dourie Voe, 1861.
—— *tricarinatus*, n. sp. Right chelate foot much larger than left ; metacarpus nearly smooth above, but having a few slender porrected spines on the distant margin, below (as well as succeeding joints) tuberculate ; wrist spinosely tuberculate ; hand ovate, broad, with three much raised keels, one median and two lateral, which are denticulate on the crest ; surface of hand, in the hollow between the keels, tuberculate ; finger broad, flattened, having the outer margin covered with much elevated tubercles. Left hand and wrist narrow, pinched up (as in *P. pubescens*) into a spine-crowned keel ; outer margin of hand with a row of spines. First two pair of walking legs having the upper margin spined. All the limbs slightly hispid, the hairs more especially developed on the left cheliped. Length $1\frac{3}{4}$ inch. Three examples dredged in deep water in 1867.

There are two Mediterranean species to which this fine *Pagurus* closely approaches, *Pagurus angulatus*, Risso, and *Pagurus meticulosus*, Roux. The figures of the former would well accord with *P. tricarinatus*, were it not that the keels of the hand are smooth instead of strongly tuberculate ; and the latter appears to differ from our Shetland form in the more elongated hands. It is, however, not improbable that the *Pagurus* here described may hereafter prove to belong to one of these southern species.

Order MACRURA.

Galathea strigosa (Linn.).
—— *squamifera* (Montagu).
—— *nexa*, Embleton. Rare, one specimen only, near Whalsey Skerries, 1861.
—— *intermedia*, Lilljeborg (*G. Andrewsii*, Kinahan). Not common. I am indebted to Prof. Lilljeborg for typical specimens of this species, which

enable me to identify it with the British *G. Andrewsii*, and to correct an error I had fallen into in considering it, from his description, to be synonymous with *G. dispersa*, Bate.

Galathea dispersa, Bate. Abundant.

Munida Bamffia (Pennant) (*M. Rondeletii*, Bell).

Homarus gammarus (Linn.).

Crangon vulgarus, Fabr.

—— *Allmanni*, Kinahan. Everywhere in deep water. It is unquestionably distinct from the last, which never occurs in deep water.

—— *fasciatus*, Risso. Five specimens, 1868.

—— *nanus*, Kröyer (*C. bispinosus*, Hailstone). 5–8 miles east of Balta, 40–50 fathoms, common; also Whalsey Skerries Haddock ground, and occasionally elsewhere.

—— *trispinosus* (Hailstone). One specimen near Balta, 1863.

—— *spinosus*, Leach. Common.

—— *serratus*, Norman, Brit. Assoc. Report, 1861 (1862), p. 151 = *C. echinulatus*, M. Sars, Videnskabs Selsk. Forhandl. i Christiania, 1861, p. 186. This species was discovered by Prof. Sars and myself about the same time. In 1861 two specimens were taken sixty miles east of Shetland; it was not again procured in Shetland until 1867, when it was met with in St. Magnus Bay.

Sabinæa septemcarinata (Sabine). The only known British example was dredged, in company with the last, in 80–90 fathoms, in 1861.

Nika edulis, Risso. Very local; abundant in one day's dredging, 25 miles N. by E. from Unst, 90–100 fathoms, 1863; St. Magnus Bay, 1867.

Doryphorus Gordoni, Bate. Deep water, very local.

Hippolyte varians, Leach (*H. smaragdina*, Kröyer).

—— *pusiola*, Kröyer (*H. Andrewsii*, Kinahan, *H. Barleii*, Bate).

—— *Cranchii*, Leach. Rare, and only the variety with the extremity of rostrum trifid (= *H. mutila*, Kröyer = *H. Yarrellii*, Thompson).

—— *pandaliformis*, Bell. Very fine; abundant in the West Voe, Whalsey Skerries, 1861; also Balta, 1863, and Hillswick, 1867; always in laminarian zone.

—— *securifrons*, Norman. Not uncommon in deep water.

—— *cultellata*, Norman, Brit. Assoc. Report, 1866 (1867), p. 200. Two specimens 40 miles east of Whalsey Skerries in 1861, then recorded as "*H. polaris*." There are certain particulars, however, in which Kröyer's description does not accord with the British form, though an actual comparison of specimens may hereafter prove them to belong to the same species.

Pandalus annulicornis, Leach.

—— *brevirostris*, Rathke (*Hippolyte Thompsoni*, Bell, *Pandalus Jeffreysii*, Bate). Very common.

Palæmon squilla (Linn.). Tidemarks, Lerwick, rare, 1861.

Order STOMAPODA.

Lophogaster typicus, M. Sars, Skand. Naturf. Möte Christiania, 1856, p. 160, Christiania Universitets-program, 1862. *Ctenomysis alata*, Norman, Report British Association, 1861 (1862), p. 151. One specimen, Outer Haaf, Whalsey Skerries, in 1861; a second, Unst Haaf (?), 1868. This species, described by me in 1861, was the subject of a most elaborate monograph by Professor Sars in the following year.

Thysanopoda norvegica, M. Sars, Om Slægten *Thysanopoda* og dens norske 1868.

Arter (Videnskabs Selsk. Forhandl. for 1863), p. 2. Some young *Thysanopodæ* were taken in the surface-net at the Out Skerries in 1861; but only one specimen is sufficiently developed to enable me to feel confident that it has acquired the characters of the adult, and that one being a male, which is not separately described by Sars, I feel some doubt as to the identification, more especially as the young females differ in some respects (which may be the result of age) from Sars's description.

Mysis flexuosa (Müller)=*Mysis chamæleon*, Bell, Brit. Crust. p. 336. Common in rock-pools.

—— *inermis*, Rathke, Beitr. zur Fauna Norw. Nov. Act. Cæs.-Leop. xx. p. 20; Lilljeborg, Öfvers. af Vet. Akad. Förhandl. 1852, p. 3; Frey u. Leuckart, Beiträge zur Kenntniss, Wirbellos. Thiere, p. 160; G. O. Sars, Beretning (1863) Zool. Reise i Christiania (1864), p. 16, = *Mysis cornuta*, Naturhistorisk Tidsskrift, Tredie Række, vol. i. (1861) p. 26, pl. i. fig. 3, *a–g*; Göes, Crust. Decap. Podoph. Sueciæ, p. 14.

Antennal scale oblong, 4–5 times as long as broad, not half as long again as peduncle of upper antennæ, about twice as long as the eye; apex very obliquely truncate, a spine at the external angle; outer margin smooth. Rostrum distinctly produced into a triangular spine of moderate length. Eye-stalks ornamented with dendritic pigment markings. Pereiopods with the propodos 4-articulate; nail well formed. Telson closely resembling that of *M. flexuosa*, the cleft slightly deeper and narrower; 16–18 spines on each side, greatest distance between the last and penultimate spine. Fourth abdominal foot in male less slender and more evenly rounded throughout its length than that of *M. flexuosa*, to which, in its general character, it closely approaches; antepenultimate joint not having any angular projection at its extremity; its seta fully half as long as penultimate joint, which does not exceed the last joint in length.

Distinguished from *M. flexuosa* chiefly by its large and acuter rostrum, and its shorter antennal scale. Rock-pools, Shetland, scarce; also Cullercoats, Northumberland (A. M. N.), and Banff (Mr. Edward).

—— *spiritus*, Norman, Ann. Nat. Hist. Dec. 1860, pl. viii. fig. 1; Trans. Tyneside Nat. Field Club, vol. iv. p. 329, pl. xvii. fig. 1; G. O. Sars, Beretning (1865) Zoologisk Reise ved Kysterne af Christianias og Christiansands Stifter, 1866, p. 19. 5–8 miles off Balta, 40–50 fathoms, 1867.

The following are important characteristics of this species, to distinguish it from the next:—Antennal scale not widening from base to the spine on external margin, that spine (in both sexes) at about three-fifths of the distance from the base to the extremity. Eyes on long stalks, which project beyond sides of carapace. Inner margin of inner uropods with a dense crowded row of unequal-sized spines, so closely packed as to touch each other at their bases. Male having the sexual lobe of superior antennæ much shorter than the peduncle; the fourth foot of pleon with the first three joints subequal in length, and the last joint subequal to the fourth.

—— *ornata*, G. O. Sars, Beretning (1863) Zoologisk Reise i Christiania-stift. 1864, p. 18.

Eyes short, scarcely reaching beyond the sides of the carapace, and thick, widening at the cornea, which is somewhat kidney-shaped. Superior antennæ with a stout peduncle, which is shorter than the peduncle of the inferior antennæ; flagella longer than the pereion. Inferior

antennæ having basal joint very short, triangular, the second long, the third two-thirds length of second; flagellum long; antennal scale about one-third longer than the peduncle, widening from the base to the spine of external margin, thence narrower by a very oblique truncation to the apex; the very large spine in the middle of the external margin; external margin below the spine naked, beyond the spine, apex, and inner margin with long plumose setæ, the second joint of scale having one seta on each side and three terminal. Last joint of pereiopods 7-articulate. Sixth segment of pleon only slightly longer than fifth. Telson subequal in length to inner lamellæ, and longer than preceding segment; lateral spines 25–30; cleft moderately deep, and wide toward the extremity, the sides being only slightly convex, and the serration longer and larger than usual distally. Inner uropods furnished with long plumose setæ all round, and a row of 16–19 rather long subequal spines, separated from each other on the inner margin. Outer lamellæ narrow, and of nearly equal breadth throughout, nearly half as long again as the inner. The male has the sexual lobe of the superior antennæ unusually long, as long as the whole peduncle. The antennal scale is narrower than in the female, the spine nearer the apex than the base, and the breadth not greater at that point than nearer the base. The fourth foot of pleon is very long, and reaches beyond the telson; the outer branch very like that of *M. spiritus*, but the third joint is much longer than either of the two first, which are subequal; fifth joint not more than half the length of the fourth. Animal more or less tinted with yellowish or red. A specimen sent to me by Mr. Edward of Banff was of a very delicate rose-colour.

Taken 5–8 miles east of Balta, in 40–50 fathoms; and also off Seaham on the Durham coast (A. M. N.), Banff (Mr. Edward).

Mysis vulgaris, J. V. Thompson. In the stream which runs into Deal Voe, near Lerwick.

Mysidopsis didelphys (Norman). *Mysis didelphys*, Tyneside Nat. Field Club, vol. v. p. 270, pl. xii. figs. 9–11; *Mysidopsis didelphys*, G. O. Sars, Beretning (1863) Zoologisk Reise i Christiania-stift. (1864) p. 27. Rare, 5–8 miles east of Balta, 40–50 fathoms.

——? *hispida*, n. sp. Body hispid all over, the hispidity evident even on the peduncles of the eyes. Eye-stalks of moderate length. Carapace produced into a broadly triangular rostrum of considerable length, reaching beyond the middle of the first joint of the superior antennæ; a notch on each side of the front margin of carapace opposite the centre of the insertion of the eye. Superior antennæ with peduncle twice as long as the eye-stalk; first joint long, slender, very concave above, two following much thicker, the third double the length of the second, hispid like the body. Inferior antennæ with peduncle only reaching the extremity of the penultimate joint of the superior; scale produced, slenderly subulate, nearly twice as long as peduncle of superior antennæ (somewhat less in ♂), two-jointed, second joint one-third total length, both margins fringed with long plumose setæ, the second joint having on each side four lateral at long intervals, and three terminal. Last joints of pereiopods 4-articulate, first articulation as long as the two following. Pleopods as in *Mysis*. Telson linguiform, long and narrow, subequal to preceding segment; sides margined with 30–35 spines, which are of equal length at first, but towards the extremity much larger spines alternate at various distances (*e. g.* every

second, third, fifth, or seventh) with smaller spines, the rounded entire apex terminating in four spines, the outer pair much longer than the middle pair; on examining the telson from below, it is seen to form, for about half its length, an open tube, the opening consisting of a central slit, the margins of which are edged with small spines. Interior lamellæ swollen at the base for the reception of the acoustic organ, but afterwards very narrow, slightly longer than telson. Outer lamellæ remarkably long and very narrow, fully half as long again as inner pair; both margins of both pairs fringed throughout with long plumose setæ; inner margin of inner lamellæ also closely beset with spines, which are of unequal size.

In the male, the superior antennæ have the last joint of the peduncle furnished with the usual lobe and dense tuft of hair. All the pleopods have a stout, large basal joint, which gives support to two branches, the inner of which in the last four pair is multiarticulate and setose, and gives off, close to the base, a small lateral lobe terminating in short setæ, but in the first pair the inner branch is rudimentary. The outer branch in the first three and the last pair is also multiarticulate and setose, but in the fourth pair is a more complicated organ, and consists of six joints at the base, all furnished on each side with a long plumose seta, and two branches of equal length, one slender, one-jointed, of equal thickness throughout, ciliate, the other having a much stouter basal joint and two multiarticulate ciliated filaments.

A single male in 40–50 fathoms, 5–7 miles off Balta, in 1857; and both sexes previously sent to me by Mr. Edward from Banff.

The descriptions of *Mysis gracilis* and *M. linguura*, G. O. Sars, come very near to the female of this species, but the present is at once distinguished by having the antennal scale two- and not three-jointed.

Genus Gastrosaccus, Norman.

A genus of *Mysidea*. Female: marsupial pouch attached to last segment of percion and first of pleon. First pleopod composed of a much elongated basal joint, and two short one-jointed branches; second to fifth pairs consisting of a single joint. Male having all the pleopods consisting of a basal joint, and two branches differently developed on the different segments, and the third pleopod the greatly developed sexual organ.

Gastrosaccus sanctus (Van Ben.)=*Mysis sancta*, Van Beneden, Recherch. sur la Faune Litt. de Belgique, Crustacés (1861), p. 17, pl. vii. figs. 1–4 (*the male*), = *Mysis spinifera*, Göes, Crust. Decap. Podophth. marina Sueciæ (1863), p. 14 (*the female*),=*Gastrosaccus sanctus*, Norman, Rep. Brit. Assoc. 1867 (1868), p. 438.

Female.—Sides of carapace extending much beyond the dorsal portion, which has its margin elegantly scalloped; fifth segment of pleon producing backwards on the back into a well-developed spine. Rostrum slightly produced, rounded at the extremity. Eyes cylindrical, on short peduncles. Superior antennæ with greatly developed peduncles; first joint as long as two following, cylindrical, smooth; second joint half length of last, with three large spines in a longitudinal row on the outer margin; filaments long and slender, the outer with its first joint long (equal about eleven of inner), and furnished on its inner face with a cutaceous process, apically setose, which reminds us of the lobe of the males of *Mysis*. Inferior antennæ having peduncle reaching the last joint of peduncle of superior antennæ; scale short, subequal in length

to the penultimate joint of the peduncle, subquadrate; external margin smooth, terminating in a spine; apex obliquely truncate, not extending beyond level of the tip of the spine of outer angle; inner margin and apex with plumose setæ. Mandible palp three-jointed, last two joints long, subequal, last slender, both setose. Flattened scalar basal joint of pereiopods having a naked external margin, terminating in a spine-like point. Last portion of pereiopod multiarticulate; in last pair articulations thirteen in number, each with a spine on both margins, and spine-like setæ on inner margin. Marsupial pouch attached to last pereiopods and first pleopods; the latter composed of a long basal joint (closely resembling a thigh-bone in form), naked during its length, but having at the base a little lobe, bearing four long plumose setæ, and having its expanded apex surrounded with a circlet of similar long setæ, within which the two little branches in which the member terminates nestle; these branches one-jointed, terminated by setæ; one branch half the length of the other. The remaining pleopods, in the form of a narrow scale, furnished with plumose setæ. Telson cleft at the apex to about one-fifth of its length; sides furnished with 7–9 spines of great size, more especially the distal ones, which are equal in length to the cleft; cleft margined with rather long, sharp, slender serrations. Inner laminæ subequal in length to (spines of) telson, narrow, fringed with long setæ, and inner margin also with about ten slender spines; acoustic organ unusually small. External laminæ shorter than inner, rounded on apex; outer margin having about twelve greatly developed curved spines instead of the usual plumose setæ.

Male.—The male, instead of having a separate lobe to superior antennæ, as in *Mysis,* has the first joint of external filament expanded in a similar manner to the female, but is more strongly developed. All the pleopods composed of a large basal joint (in the first furnished with large plumose setæ, in the others naked) and two branches; first, fourth, and fifth pairs with outer branch half as long again as peduncle, multiarticulate and setose: inner branch short, with widely diverging plumose setæ; second pair with both branches multiarticulate and plumose, the external branch rather more developed than the inner, the latter with a small lateral lobe at the base; third pair having outer branch of considerable length, consisting of four long, rounded, slender, smooth joints, the last having two minute marginal spines, and terminating in two slender spines; inner branch shorter than first joint of outer, multiarticulate and plumosely setose; basal joint giving off a small lateral lobe. Length three-quarters of an inch.

Dredged 5–8 miles east of Balta, in 40–50 fathoms; also Banff (Mr. Edward), Firth of Clyde (Mr. D. Robertson), and off the mouth of the Tees and Norfolk coast (Mr. G. S. Brady).

Genus Nematopus, G. O. Sars.

Allied to *Mysis.* Superior antennæ having first joint of peduncle with a setiferous process on the outer margin; the last joint in male with a hirsute lobed appendage. Pereiopods very long and slender, 8-jointed, nearly filiform, with very few hairs, terminating in a well-formed nail. No external branchiæ. Marsupial pouch as in *Mysis.* Pleopods in female rudimentary as in *Mysis,* but in male well developed, two-branched; branches multiarticulate; the external branch with a setiferous process on its inner margin; in the first pair the terminal part rudimentary, and without setæ. Telson

very short, scarcely longer than broad, apically broadly truncate, and terminating in four strong spines and two plumose setæ. Acoustic organ large.

Nematopus serratus, G. O. Sars, Om en i Sommeren 1862, Zoolog. Reise i Christ. og Trondhjems Stifter (1863), p. 43.

Carapace rounded in front, not produced into a rostrum, but a spine springs from between the eyes, and bears the appearance of a rostrum. Eyes reniform, clavate, wider than long. Superior antennæ with middle joint of peduncle very short, first and third subequal. Antennal scale lanceolate, about half as long again as peduncle of inferior antennæ, transversely truncate at the apex; external margin having 8–9 spine-like processes down the side (each similar in character to the single apical spine of the scale in *Mysis flexuosa* and its allies). Pereiopods remarkably long and slender, last joint terminating in a bunch of hairs. Telson not half the length of the inner laminæ, no lateral spine, distally broadly truncate, and furnished with four long spines, the inner pair the more greatly developed; in the middle between these are two plumose setæ. External laminæ considerably longer than inner, narrow, and of nearly equal width throughout; both margins of both pairs of laminæ fringed with plumose setæ, which on external margin of outer laminæ are slender and short. Colour white, with a reddish spot on each side of each segment of pleon, and a band across the fourth; sometimes also a longitudinal line on each side of the carapace. The very large reniform eyes are of a lovely and brilliant ruby-red. Length half an inch. Dredged on muddy bottom in 40–60 fathoms, St. Magnus Bay, 1867.

Order CUMACEA.

Nannastacus binoculoides, Bate, Ann. Nat. Hist. 3rd ser. vol. xv. (1865) p. 87, pl. i. fig. 4. The type specimen dredged in 1863; again in surface net, Lerwick Bay, 1867, by Mr. D. Robertson.

Diastylis echinata, Bate, Ann. Nat. Hist. 3rd ser. vol. xv. (1865) p. 87, pl. i. fig. 1. The type specimen dredged in 1863.

—— *bispinosa* (Stimpson) = *Cuma bispinosa*, Stimpson, Marine Invertebrata Grand Manan, p. 39; Danielssen, Reiseberetning i Thr. Vid. Selsk. Skrift. Bd. iv. p. 108, = *Cuma cornuta*, A. Boeck, Videnskabs Selsk. Forhandl. 1863, p. 190, = *Diastylis bicornis*, Bate, Ann. Nat. Hist. 3rd ser. vol. xv. (1865) p. 84, pl. i. fig. 2, = *Diastylis bispinosa*, G. O. Sars, Om den aberrante Krebsdyrgruppe Cumacea og dens nordiske Arter (1864), p. 39. The first British specimen dredged in Shetland in 1863, and described by Mr. Bate under the name *Diastylis bicornis*.

—— *lævis*, n. sp., =? *Alauna rostrata*, Goodsir, Edinb. New. Phil. Journ. vol. xxxiv. (1843) p. 130, pl. iv. figs. 1–10.

Pereion, viewed laterally, elongated ovate, seen from above, widest in the middle, ovate; carapace rather longer than the free segments, dorsal margin well arched, surface only slightly hispid, wholly devoid of spines; lateral margins spined; rostrum acute, slightly bending upwards. Last segment of pereion with the sides produced backwards into short blunt processes. Upper antennæ having last joint of peduncle as long as the first and longer than the second; filament as long as last joint of peduncle. First feet with the first joint very long, equal, or nearly equal, to the remaining portion of the limb; both margins furnished with plumose setæ, spinose on the side; last three joints subequal. Second feet having the fourth joint as long as the first, and longer than

the last two combined. Telson subequal to the long peduncle of lateral appendages, lageniform, gradually tapering from near the base to the extremity, about twelve spines on each side; terminal spines not larger than preceding. Lateral appendages with long and slender peduncle, with about 25–30 spines on the inner margin; inner ramus not half so long as peduncle; first joint equalling in length the two others; inner margin furnished with spines of similar character to those of peduncle, eight on first joint, three on second, four on last; the spines are peculiar, having a minute cilium springing from them at half their length: outer ramus longer than inner, ending in 3–4 long spine-like setæ; margins almost naked, only having very few scattered setæ.

Male wholly devoid of spiny armature on cephalothorax and pleon. First joints of first and second legs spinose. Telson with fewer (about eight) and much more slender lateral spines, and the terminal spines considerably larger than the others. Lateral appendages nearly as in ♀, but the branches longer, the inner more than half length of the peduncle. Length half an inch.

This seems to be the commonest species in our seas. It is nearly allied to *D. Rathkii*, but the cephalothorax is shorter and more tumid, and free from spines.

Shetland and Durham coast (A. M. N), Moray Firth (Mr. T. Edward).

Diastylis lamellata, Norman, Brit. Assoc. Report, 1866 (1867), p. 200. Two specimens, St. Magnus Bay.

—— *spinosa*, n. sp. *Male.*—Pereion, viewed laterally and dorsally elongated ovate; carapace toothed in the latero-anterior margin, and having a crested line passing from behind, very near to and subparallel with the inferior margin, which curving round in front meets the crest which comes from the opposite side at a short distance behind the rostrum; this crest, throughout the greater part of its length, is composed of little flat plates, which lie close against each other; in front, however, the line is broken up into distinct and separate spines. Rostrum with rows of small spines on each side; a slight central carina on the carapace. Segments of pereion smooth, not spined; last segment produced backwards laterally into much produced and acute processes. Pleon having each of the first five segments furnished with three more or less developed longitudinal rows of spines on the back, and two at the edges of the underside; the hindermost spine of each row the most developed. Sixth segment unspined. Superior antennæ much developed; peduncle long, last joint furnished with a dense brush of auditory cilia; filaments long. First joint of last gnathopods and of all the pereiopods with strong spines. First pereiopods with the antepenultimate joint extending beyond the rostrum; penultimate joint equal in length to third and fourth combined, last joint subequal to fourth. Second pereiopods having first joint strongly spined, second very short, fourth long and unusually slender. First pleopods with basal joint and two very unequal branches; second with two branches of nearly equal length, but one with more numerous and much longer plumose setæ than the other; infero-posteal margin of second segment of pleon with a row of (six) long plumose setæ; plumose setæ under the third and fourth segments. Telson suddenly bent downwards at a short distance from the base, gradually attenuated, much produced, but not as long as the long peduncle of uropods; twelve pairs of long, slender, lateral spines; terminal spines rather stouter. Inner margin of peduncle of uropods with numerous spines, with closely

ciliated margins; inner ramus subequal in length to outer, with inner margin of first joint spined, and clothed with dense short fur, of two following joints spined, the last with seven spines, which are more developed distally; outer ramus suddenly contracted in width on the inner margin at a short distance from the base; inner margin smooth (except quite at distal extremity, where there are two or three spine-like setæ); outer margin with spine-like (annulated?) setæ, and a row of similar setæ passing down the back, and ultimately passing obliquely to the distal extremity of the inner margin. Length half an inch.

Only the male is known to me. One specimen, Shetland, 1863, and a second received from Mr. Edward of Banff.

Eudorella truncatula (Bate)=*Eudora truncatula*, Bate, Ann. Nat. Hist. N. S. vol. xvii. (1856) p. 457, pl. xiv. fig. 3; G. O. Sars, Om den aberrante Krebsdyrgruppe Cumacea (1864), p. 61, =*Eudorella truncatula*, Norman, Brit. Assoc. Report, 1866 (1867), p. 197, note. Haddock Ground, near the Out Skerries, in 1861.

Lamprops rosea (Norman)= *Vaunthompsonia rosea*, Norman, Trans. Tyneside Nat. Field Club, vol. v. (1863) p. 271, pl. xiii. fig. 1–3 (*the female*), = *Cyrianassa elegans*, id. ib. p. 275, pl. xiv. fig. 1–6 (*the male*), =*Lamprops rosea*, G. O. Sars, Om Cumacea, p. 64. St. Magnus Bay, rare.

Cumella agilis, n. sp. *Male*.—Pereion longer than pleon, five segments uncovered by carapace. Carapace longer than free segments of pereion, much deeper in front than behind; no distinct rostrum; anterior margin deeply concave at the side; infero-anteal corner produced and toothed; teeth 2–3; surface of carapace smooth. Inferior antennæ not so long as pereion; second joint of peduncle with a dense tuft of hair above, third joint also hispid. All pereiopods, except last, furnished with a palp of unusual structure, which has a second joint which is longer than the first, and slender, not setose; then several (? five) very short setiferous joints which, combined, do not equal more than one-third length of second joint. First joint of 1st to 4th pairs of pereiopods monstrously developed, long, and very massive, while the remaining portion of the limb is very slender; first pair short, scarcely reaching extremity of the head; first joint with a long slender spine at the extremity of the hinder margin, fourth joint equalling in length the two following; third and fourth pereiopods with 2nd to 6th joints not equalling length of first; no whip-setæ; sixth joint in form of a long slender nail. No pleopods. Telson rudimentary, widely truncate at extremity. Uropods with peduncle longer than rami, a few scattered spines on inner margin; inner ramus uniarticulate, longer and much stouter than the outer, with ten spines on inner margin, increasing in size distally; outer ramus two-jointed, terminating in a long slender spine, with a minute spine on each side of it, no other spines or setæ. Length scarcely more than an eighth of an inch.

Taken abundantly (only males) in the surface-net at night in Balta Sound, 1863 (A. M. N.); and by similar means in Lerwick Bay and Kirkwall, 1867 (Mr. D. Robertson).

Iphinoë serrata, Norman, Brit. Assoc. Report, 1866 (1867), p. 201. One specimen in 70–80 fathoms, sand, Outer Haaf, Out Skerries, 1861, and again in St. Magnus Bay, 30–60 fathoms, 1867.

—— *gracilis*, Bate= *Venilia gracilis*, Bate, Ann. Nat. Hist. 2nd ser. vol. xvii. (1856) p. 460, pl. xvi. fig. 7, =*Cyrianassa gracilis*, Bate, Ann. Nat. Hist. 2nd ser. vol. xviii. (1856) p. 187. Rare, near Balta Sound, 1863, in towing-net.

The genus *Cyrianassa* is founded on the male of *Iphinoë*. The genus is characterized (chiefly) by having the pereion very long, five segments uncovered by carapace, and its posterior segments scarcely deeper than those of pleon; the last four pereiopods in both sexes without a palp; the telson rudimentary; the uropods with both branches biarticulate, the inner strongly spined: and in the male by having the first five segments of pleon furnished with well-developed biramous pleopods. I am by no means certain that the present species is not the male of *Iphinoë trispinosa*. Undoubted males of that species resemble the *I. gracilis* very closely, except that they have 2–3 spines on carapace, and the pleopods have not the long plumose setæ which adorn those of the latter species. It is possible, however, that the development of these setæ may depend upon age, and that the presence or absence of the small dorsal spines may not constitute more than varietal distinction. Future observation must be left to clear up this point.

Cuma scorpioides, Bate, Ann. Nat. Hist. 2nd ser. vol. xvii. (1856) p. 456, pl. xiv. fig. 2, =? *Cancer scorpioides*, Montagu, Linn. Trans. vol. ix.

Taken in Balta Sound in 1863. Known by its strong angular and keeled carapace. Only four segments of pereion are exposed, and the penultimate and the antepenultimate of these are raised into a rounded rib across the back. The uropods have both branches two-jointed, and only half as long as peduncle, subequal to each other, inner with numerous short blunt spines, but the two distal ones of each joint long, outer with plumose setæ on the inner margin; peduncle without spines or setæ, but minutely serrulate on inner margin. The male, as in *Iphinoë*, has five well-developed pairs of pleopods.

Order AMPHIPODA.

Talitrus locusta (Linn.).

Orchestia littorea (Montagu).

Probolium monoculoides (Montagu)=*Montagua monoculoides*, Bate & Westwood. Bressay Sound, and 5–8 miles off Balta, 50 fathoms. Costa's genus *Probolium* (Ricerche sui Crostacei Amfipodi del regno di Napoli, 1853, p. 199) is synonymous with, and has precedence of, Bate's *Montagua*, which was established in 1855.

—— *marinum* (Bate)=*Montagua marina*, Bate & Westwood. 5–8 miles east of Balta, 50 fathoms, and on the Skerries Outer Haaf, in 70–80 fathoms.

—— *Alderi* (Bate) = *Montagua Alderi*, B. & W. A single specimen of what I consider a variety of this species taken in Lerwick Bay. It differs from the ordinary form in having the hand of the second gnathopods longer, being more than twice as long as broad, and in the palm being less oblique, crenately toothed throughout (instead of in part only), and the projecting tooth-like process bounding the palm of smaller size.

—— *serratipes*, n. sp. Antennæ rather short. Second gnathopods with the metacarpus posteally produced into a small tooth-like process; wrist produced below into an elongated lobe, which stretches along the posterior margin of the hand (after the manner of the genus *Monoculodes*) to half its length, and terminates in two or three setæ; hand of large size, elongated, of somewhat unusual form, widest in the middle, from which point the posterior margin gently slopes towards the anterior

margin, both towards the base and towards the finger, at this point the elongated lobe of the wrist terminates and the palm begins; this is gently arched, sloping away to the base of the claws, with the margin denticulately serrated throughout (no spines or larger teeth); finger as long as the palm, slender, curved correspondingly to the palm. First and second pereiopods slender, propodos and nail long. Last pereiopods having the metacarpus infero-posteally produced (as is usual in the genus) to half the length of the wrist; no portion of the limb serrated. Length one-twelfth of an inch. One specimen, dredged in about 50 fathoms in St. Magnus Bay, 1867. *Probolium polyprion*, Costa, agrees with the present species in having a serrated palm to the second gnathopods, but differs in the form of the hand, and the presence of spines at the distal extremity of the palm, in the wrist not being produced, and in the anterior margin of the last pair of pereiopods being serrated.

Probolium pollexianum (Bate) = *Montagua pollexiana*, Bate & Westwood. 5–8 miles east of Balta in 50 fathoms; apparently rare in Shetland, one specimen only having been found.

Lysianassa Costæ, M.-Edwards. Scarce.

—— *Audouiniana*, Bate. A specimen taken among Laminariæ, 3–5 fathoms, Out Skerries Harbour, in 1861, and then submitted to Mr. Bate, was considered by him to be a "black-eyed variety" of this species.

—— *longicornis*, Lucas. One specimen, 20–25 miles north of Burrafirth Lighthouse in 1863.

Anonyx longicornis, Bate. A few specimens, deep water, St. Magnus Bay. This species is recognized instantly by the peculiar dorsal and lateral angles of the body, and the curious hooded form of the large first joint of the superior antennæ.

—— *serratus*, A. Boeck, Forhandl. ved de Skand. Naturs. 8 de Möde, 1860, p. 641; Lilljeborg, Crustac. Lysianassina of Norway and Sweden, 1865, p. 29. *Anonyx Edwardsii*, Bate & Westwood, Brit. Sessile-eyed Crust. vol. i. page 94 (but not *A. Edwardsii* of Kröyer). Dredged in Vidlom Voe, and between tide-marks at Lerwick in 1861.

—— *Holböllii*, Kröyer, Naturhist. Tidsskr. 2 Række, Bd. ii. p. 8; Voyage Scand. Crustac. pl. xv. figs. 1, *a–s*; Lilljeborg, Crust. Lysianassina of Sweden and Norway, p. 31; Bruzelius, Skand. Amphip. Gammaridea, p. 43 (but not *A. Holböllii* of Bate and other British authors), = *Anonyx denticulatus*, Bate & Westwood, Brit. Sessile-eyed Crust. vol. i. p. 101.

Common, Bressay Sound, 15 fathoms; Bressay Sound, 7 fathoms; off Balta, 50 fathoms; Balta Sound and St. Magnus Bay.

—— *gulosus*, Kröyer, Naturhist. Tidssk. Anden Række, 1 Bd. p. 611; Voyage en Scandinavie, pl. xiv. fig. 2; Bruzelius, Skand. Amphip. Gamm. p. 44; Lilljeborg, Crust. Amphip. Lysianassina, p. 24, = *Lysianassa gulosa*, Göes, Crust. Amphip. maris Spetsbergiam alluentis, p. 4, = *Anonyx Holböllii*, Bate & Westwood, Brit. Sessile-eyed Crust. vol. i. p. 104 (but not *A. Holböllii* of Kröyer).

2–5 fathoms, Out Skerries Harbour, among Laminariæ, 1861.

—— *nanus*, Kröyer, Naturhist. Tidsskr. 2 Række, 2 Bd. p. 30; Lilljeborg, Crust. Amphip. Lysianassina, p. 28.

Dredged in deep water, St. Magnus Bay, 1867. New to Britain. I have received it also from Mr. D. Robertson, who took it in the surface net in the Firth of Clyde; and from Mr. Laughrin from Polperro, where it would seem to be remarkably abundant.

Anonyx nanoides, Lilljeborg, Crust. Amphip. Lysianassina, p. 25, pl. iii. figs. 32–34, =? *Anonyx nanus*?, Bruzelius, Skand. Amph. Gammaridea, p. 42.

Another addition to our fauna, procured in 1867, in shallow water, in Bressay and Balta Sounds, among Laminariæ.

—— *plautus*, Kröyer. Mr. Spence Bate doubtfully referred to this species an *Anonyx* from the laminarian zone in the Out Skerries Harbour, procured in 1861.

—— *longipes*, Bate. *A. longipes*, Bate & Westwood, British Sessile-eyed Crust. vol. i. p. 113, *the female*, =*A. ampulla*, Bate & Westwood, *l. c.* p. 116, *the male* (but not *A. ampulla* of Kröyer), =*A. longipes*, Lilljeborg, Crust. Amphip. Lysianassina, p. 23, pl. iii. figs. 23–31. Prof. Lilljeborg is unquestionably right in considering the *A. ampulla* of the 'British Sessile-eyed Crustacea' to be the male of *A. longipes*. I have taken both sexes in Balta Sound and in St. Magnus Bay. The true *A. ampulla* of Kröyer is the next species which is now added for the first time to our fauna.

—— *ampulla* (Phipps). *Cancer ampulla*, Phipps, Voyage towards the North Pole, 1773, p. 191, pl. xii. fig. 2, = ♀ *Anonyx lagena*, Kröyer, Grönlands Amphipoder, p. 237, pl. i. fig. 1; M.-Edwards, Hist. Nat. des Crustac. vol. iii. p. 21; Bate, Cat. Amphip. Crust. p. 77, pl. xii. fig. 7; Göes, Crust. Amphip. maris Spetsber. alluentis, p. 2, = ♂ *Anonyx appendiculosa*, Kröyer, Grönlands Amphipoder, p. 240, pl. i. fig. 2; M.-Edwards, Hist. Nat. des Crust. iii. p. 21, =*Anonyx ampulla*. Kröyer, Naturhist. Tidsskr. Anden Række, Bd. i. p. 578; Voyage en Scandinavie, pl. xiii. fig. 2; Bruzelius, Skand. Amphip. Gamm. p. 39; Lilljeborg, Crust. Lysianassina of Norway and Sweden, p. 23 (but not *A. ampulla* of Cat. Amphip. Crust. Brit. Mus. nor of Sessile-eyed Crustacea).

This *Anonyx*, the specimens agreeing in all respects with Spitzbergen examples, received from Prof. Lovén, except that they are not more than a quarter the size, was procured on the Out Skerries Middle Haaf, in 1861. It occurred in hundreds upon a fish which had been brought up dead on a fisherman's long line. It would appear to be one of the scavengers of the seas; for Göes also writes of it, "Ad Spetsbergiam inter algas, præsertim fundo arenoso et argillaceo profunditate orgyarum trium usque ad sexaginta copia stupenda, eo ut, si perite ac prudenter in captura versaris, hos pelagi voracissimos vespellones molibus milliariis cadavere avium vel phocarum brevi e fundo elicere potes." The contour of this *Anonyx* is peculiarly rounded and smooth, by which character it may, without microscopic examination of the limbs, be distinguished from *longipes*. It is now first added to our fauna.

—— *tumidus*, Kröyer, Naturhistorisk Tidsskr. Anden Række, Bd. ii. p. 16; Voyage en Scandinavie, pl. xvi. fig. 2; Bruzelius, Skand. Amphip. Gammarid. p. 41; Spence Bate, Cat. Amphip. Brit. Mus. p. 73; Lilljeborg, Crust. Amphip. Lysianassina, p. 32, pl. iv. fig. 51; Heller, Amphip. des adriatischen Meeres, p. 25, pl. iii. fig. 6–12, =*Lysianassina tumida*, Göes, Crust. Amphip. maris Spetsbergiam alluentis, p. 2.

A single specimen taken in the branchial sac of an Ascidian in 1863, and many more in 1867, living in a fine undescribed sponge, *Raphioderma coacervata* of this Report, which was dredged 25–30 miles N.N.W. of Burrafirth Lighthouse in 170 fathoms.

—— *melanophthalmus*, Norman, Brit. Assoc. Report, 1866 (1867), p. 201. One, 5–8 miles off Balta, in 50 fathoms, 1867.

Acidostoma obesum (Bate), =*Anonyx obesus*, B. & W., Brit. Sessile-eyed Crust. vol. i. p. 98, =*Acidostoma obesum*, Lilljeborg, Crust. Lysianassina, p. 34, pl. v. fig. 53–65. St. Magnus Bay, in deep water.

Callisoma crenata, Bate. Out Skerries, Middle Haaf, 40 fathoms; off Isle of Balta, 40–50 fathoms; St. Magnus Bay.

Stegocephalus ampulla (Phipps), *Cancer ampulla*, Phipps, Voyage toward the North Pole, 1774, p. 191, pl. xii. fig. 3, =*Stegocephalus inflatus*, Kröyer, Naturhist. Tidsskr. Förste Række, Bd. i. p. 150; Bruzelius, Skand. Amphip. Gammarid. p. 38, =*Stegocephalus ampulla*, Bate, Cat. Amphip. Brit. Mus. p. 63, pl. x. fig. 2; Göes, Crust. Amphip. maris Spetsberg. alluentis, p. 5.

A female laden with eggs was dredged in 1867 in St. Magnus Bay, in about 50 fathoms. It was not quite a quarter of an inch in length, a pigmy compared with its giant brethren from Spitzbergen, with which, however, it agrees closely in all particulars. This arctic species is a very interesting addition to the British fauna.

Opis leptochela, Bate & West. MS. "Shetland, received from Mr. Jeffreys," Bate in litt. A species not yet described.

Pontoporeia affinis, Lindström, Öfvers. af K. Vet. Akad. Förh. 1855, p. 63; Bruzelius, Skand. Amphip. Gammarid. p. 48; Bate, Cat. Amphip. Brit. Mus. p. 83, pl. xiv. fig. 2. "Shetland, from Mr. Jeffreys," Bate in litt.

Ampelisca æquicornis, Bruzelius, Skand. Amphip. Gammarid. p. 82, pl. iv. fig. 15.

Superior antennæ much longer than peduncle of inferior; third joint half length of first, and scarcely more than one-fourth of second. Inferior antennæ with last two joints of peduncle subequal, both pairs of antennæ fringed with long hairs, and speckled with crimson throughout, a stain of the same colour at the joints of the peduncle; nail of first two pairs of pereiopoda longer than the two preceding joints combined. Last pereiopods having the posterior lobe of the basos produced downwards to the distal extremity of following joint, rounded inferiorly; meros not posteally produced; propodos and nail broad and flat. Inferoposteal angle of third segment of pleon not produced. Last uropods much longer than preceding pairs, branches nearly as long again as peduncle. Telson cleft almost to the base, reaching one-third the length of the branches of last uropods. Generally a conspicuous hump on the back of the fourth segment of pleon, and a hollow in the back of the sixth. A common species in our seas. Shetland, Skye, Northumberland and Durham coasts, Guernsey.

—— *tenuicornis*, Lilljeborg, Öfvers. af Kong. Vet. Akad. Förhand. 1855, p. 123; Bruzelius, Skand. Amphip. Gammarid. p. 84; Bate, Cat. Crust. Amphip. Brit. Mus. p. 96.

Head produced, obliquely truncate in front, the antennæ attached to the oblique truncation and directed downwards. Superior antennæ about equal in length to peduncle of inferior; second joint of peduncle much more slender than first; third joint scarcely differing in size or length from the joints of the filament, rather more than half length of second. Inferior antennæ with last two joints subequal, very long and slender; filament very long and slender; antennæ speckled with red. Nail of first two pairs of pereiopoda longer than two preceding joints combined. Last pereiopods having the posterior lobe of the basos produced downwards to the distal extremity of the following joint, rounded inferiorly; meros not posteally produced; propodos and nail

not very broad or much flattened. Infero-posteal angle of third segment of pleon not produced. Last uropods much longer than preceding pairs; branches about half as long again as peduncle. Telson cleft nearly to the base, equal in length to the penultimate uropods, and reaching to one-third the length of the rami of the last pair.

A smaller species than the last, distinguished by the oblique truncation of the extremity of the head, and by the slenderness of the antennæ, and their great difference in length. It is usually prettily painted with lilac or rose-colour about the lower parts. Shetland, Skye, Guernsey (A.M.N.), and Aberdeenshire (Mr. Dawson). I have had the opportunity, through the kindness of Professor Lovén, of comparing the individuals here described of this species and of *A. lævigata* with Bohuslän examples, and thus am enabled to speak positively as to their identity.

Ampelisca carinata, Bruzelius, Skand. Amphip. Gammarid. p. 87, pl. 4. fig. 16; Bate, Cat. Amphip. Crust. Brit. Mus. p. 371, =*Ampelisca Gaimardi*, Bate, Cat. Amphip. Crust. Brit. Mus. p. 91; Bate and Westwood, Brit. Sessile-eyed Crust. p. 127 (but not *A. Gaimardi* of Kröyer and Bruzelius).

Head vertically truncate. Superior antennæ a little longer than peduncle of inferior; peduncle reaching middle of penultimate joint of peduncle of inferior; second joint scarcely longer than first; third joint about one-third as long as second; lower side of whole peduncle beset with numerous transverse tufts of short hair; first joint of filament larger than usual, looking more like a joint of the peduncle, furnished below with a bunch of (? auditory) setæ. Inferior antennæ extremely long, equalling whole length of animal; upper margin of peduncle clothed with transverse rows of tufted hair, similar to those on lower side of superior antennæ; last joint nearly half as long again as penultimate; filament very slender. Nails of first two pairs of pereiopoda not longer than two preceding joints combined. Two last segments of pleon (fifth and sixth are coalesced into one) elevated dorsally into very conspicuous humps. In other respects agreeing closely with *A. æquicornis*, of which species I strongly suspect that it is the male. Shetland (A. M. N.); Kirkwall Bay, Orkney (Mr. D. Robertson); Aberdeenshire coast (Mr. Dawson).

The species described by British authors as *A. Gaimardi* is unquestionably the *A. carinata* of Bruzelius; the true *A. Gaimardi*, according to that author's characters, differs from all British forms in the structure of the last uropods and telson. "Pedes abdominis ultimi paris duo paria antecedentia haud superantes. Appendix caudalis brevis, lata, parum fissa."

—— *lævigata*, Lilljeborg, Öfvers. af Kong. Vetensk. Akad. Förhandl. 1855, p. 123; Bruzelius, Skand. Amphip. Gammarid. p. 84; Bate, Cat. Amphip. Crust. Brit. Mus. p. 96.

Head much produced, squarely truncated in front. Superior antennæ very short, not reaching end of penultimate joint of peduncle of inferior; second joint of peduncle half as long again as first, third joint closely resembling joints of filament, which are only about six. Inferior antennæ with a very long peduncle, the last joint distinctly shorter than preceding. First and second pereiopods having the nails very long, considerably longer than the two preceding joints combined. Last pereiopods having the posterior lobe of the basos produced downwards to the distal extremity of the following joint, truncate inferiorly, and closely fringed with long plumose setæ; meros produced backwards and downwards

into a rounded lobe of considerable size, fringed with plumose setæ; carpus antero-distally bearing a circlet of strong spines; propodos much flattened and expanded. Third segment of pleon having the posterior margin waved, and produced backwards at the infero-posteal angle into an acute hastate point. Telson cleft almost to the base, having a row of spine-like hairs down middle of each portion, reaching to the middle of the branches of the last uropods, which are much longer than the preceding pairs. Balta Sound and St. Magnus Bay, Shetland (A. M. N); Kirkwall Bay, Orkney (Mr. D. Robertson); Aberdeenshire (Mr. Dawson).

[*Ampelisca macrocephala*, Lilljeborg, Öfversigt af Kong. Vetensk. Akad. Förhandl. 1852, p. 7, and 1855, p. 137; Bruzelius, Skand. Amphip. Gammarid. p. 85; Bate, Cat. Crust. Amphip. Brit. Mus. p. 94, agrees with *A. lævigata* in having the infero-posteal angle of the third segment of the pleon produced backwards into a spine-like point, but differs in that the meros of the last pereiopods has no posterior lobe. I have dredged it in the Sound of Skye. The *Ampelisca Belliana* of Bate appears to be referable to this species.]

Phoxus Holbölli, Kröyer. Out Skerries Harbour, 3–5 fathoms; St. Magnus Bay.

—— *plumosus*, Kröyer. Balta Sound, St. Magnus Bay; Outer Haaf, 3–90 fathoms.

Œdiceros parvimanus, Bate & Westwood. The type specimens were procured in 1861, in 70–90 fathoms, sixty miles east of Shetland; and I have since found it in other directions on the Haaf, and very abundantly on the soft muddy ground of St. Magnus Bay.

—— *æquicornis*, n. sp. Rostrum extending beyond the first joint of upper antennæ. Upper antennæ having the three joints of the peduncle of nearly equal length, each more slender than preceding; filament equal the length of last two joints of peduncle, composed of five long articulations. Lower antennæ slender but short; peduncle exceeding the length of that of superior by nearly the last joint, which is equal in length to the penultimate; filament very slender, 4–5 jointed, equal in length to the last joint of peduncle. First gnathopods with wrists inferiorly produced into a wide rounded lobe reaching forwards to the commencement of the palm; hand obovate, widest in the centre where the palm commences, which is very oblique; finger slender, simple, as long as palm. Second gnathopods very like the first, but the hand slightly larger, and rather more elongated. All the pereiopods with very long and nearly straight nails, which about equal the propodos in length; propodos much longer than carpus. Penultimate pereiopods with a row of setæ down the middle of the basos. Last pereiopods with the basos small, elongated, pear-shaped, equally produced anteally and posteally; both margins with small cilia, the hinder margin also crenated; the last four joints all greatly produced, and each longer than the basos; the whole limb very long. Length about one-fourth of an inch. A single specimen from St. Magnus Bay, in 30–60 fathoms, 1867. *Œ. æquicornis* comes near to *Œ. brevicalcar* of Göes; but his figures represent the hands narrower in proportion to the wrists than in the present species, and there are other slight points of difference. He does not describe or figure the last pereiopods, which are the most characteristic organs in *Œ. æquicornis*.

Genus Syrrhoë, Göes.

Head produced into a rostrum. Eyes like those of *Œdiceros*. Upper an-

tennæ with a secondary appendage. Mandible having a three-jointed palp. Gnathopods not subchelate. Telson squamiform, deeply cleft.

Syrrhoë hamatipes, n. sp. None of the segments of pleon serrated or toothed. Superior antennæ with a smooth round peduncle, reaching the middle of the penultimate joint of the inferior, the first joint nearly as long as two following combined, which are subequal to each other, the last rather the shorter; filament rather longer than peduncle, composed of 7–8 long slender articulations; secondary appendage two-jointed. Inferior antennæ with a long peduncle, last joint rather longer than the first, and two-thirds as long as second; filament shorter than peduncle, 7-jointed, joints very long and slender. Gnathopods not subchelate, almost identical in structure; wrist with subparallel margins, of nearly equal breadth throughout; hand much narrower than and about two-thirds the length of wrist, which it resembles in form; posterior margins of both wrist and hand with numerous plumose setæ; anterior margin with two or three such setæ; finger two-thirds length of hand, only very slightly curved, not capable of being closed with the hand. Pereiopods with meros and carpus of equal length; propodos rather more than half length of carpus and much narrower; nail small, bent at right angles to propodos, and having a little spine at half its length; two spines project forwards from the extremity of the propodos, which are as long as the nail. Last pereiopods short, having the basos greatly produced backwards and downwards into a *membranaceous* lobe, which extends to the distal extremity of the meros; meros and carpus subequal in length, both very wide and flat, the latter slightly tapering distally; both margins fringed with plumose setæ, and the carpus terminating in such setæ of considerable length and extending beyond the nail; propodos styliform, much shorter than and scarcely a quarter as broad as the carpus; nail (similar to those of preceding pereiopods) slender, small, bent at right angles to the propodos, and having a little spine at half its length. Last uropods two-branched; branches subequal, lanceolate. Telson squamiform, not long, cleft to the base. Length one-fourth of an inch. One specimen, dredged in St. Magnus Bay, 1867.

I place this species provisionally in the genus *Syrrhoë*; the head having been crushed, I am unable to speak with precision respecting the eyes and rostrum.

Monoculodes carinatus, Bate=*Œdiceros affinis*, Bruzelius, Skand. Amphip. Gammarid. p. 93, pl. iv. fig. 18. St. Magnus Bay, 1867. Male and female; the antennæ much longer in the former, as is also the case with *Œdiceros parvimanus*.

—— *Stimpsoni*, Bate. Sixty miles east of Shetland, in 70–90 fathoms, one specimen, 1861.

Kröyera altamarina, Bate & Westwood. The type, taken sixty miles east of Shetland in 1861; also 5–8 miles east of Balta, in 40–50 fathoms, 1867.

Urothoë marinus, Bate. Balta Sound; 5–8 miles east of Balta, and St. Magnus Bay, 5–60 fathoms.

—— *elegans*, Bate. In the same localities as the last; also on the Out Skerries Haaf, in 60–70 fathoms.

—— *Bairdii*, Bate. St. Magnus Bay.

Lilljeborgia Shetlandica, Bate & Westw. The types were dredged in 40 fathoms, one mile north of Whalsey Lighthouse, and in 2–5 fathoms in Out Skerries Harbour in 1861.

Iphimedia obesa, Rathke. Widely distributed, 2–50 fathoms.

Odius carinatus (Bate). *Otus carinatus,* Bate & Westw. Brit. Sessile-eyed Crust. p. 224. Very rare; two specimens only, in 70–80 fathoms, sixty miles east of Shetland, 1861. The type was taken by Mr. Barlee in his last expedition to the Shetland Islands. The name *Otus* being preoccupied, Lilljeborg has substituted that of *Odius* for this genus (Lilljeborg, Crust. Amphip. Lysianas. p. 19).

Helleria coalita, Norman, Ann. Nat. Hist. 4th ser. vol. ii. (Dec. 1868) p. 418. Surface-net, Lerwick (Mr. D. Robertson).

Epimeria tricristata, Costa, Ricerche sui Crostacei Amfipodi del regno di Napoli (1853), p. 197, pl. ii. fig. 2, =*Acanthonotus Owenii,* Bate, Brit. Assoc. Rep. 1855, p. 58; Bate and Westwood, Brit. Sessile-eyed Crust. p. 232. Common in deep water. This species is well described and figured by Costa, whose name must be adopted, since the specific name is four years prior to that of Bate; and as regards the genus, *Acanthonotus* being preoccupied among the Fishes, and *Vertumnus* only a MS. title, we must also take that of the Italian naturalist.

Dexamine spinosa (Montagu). Out Skerries Harbour, Lerwick and Balta Sounds, among Laminariæ, always in shallow water.

—— *tenuicornis,* Rathke. In similar localities to the last.

—— *Vedlomensis,* Bate & Westwood. The type taken in Vidlom Voe in 1861, since dredged in St. Magnus Bay, 60 fathoms; and 5–8 miles off Balta, 40–50 fathoms.

Atylus Swammerdamii (M.-Edwards) = *Amphithoë compressa,* Lilljeborg, Öfvers. af K. Vet. Akad. Förhandl. 1852, p. 8. Bressay Sound and Hillswick, among seaweeds.

—— *gibbosus,* Bate. An interesting species on account of the peculiar character of the carpi of the pereiopoda. It appears constantly to live parasitic in sponges (*Halichondria panacea* chiefly) between tide-marks and in shallow water. Abundant in Burrafirth Caves, also Balta Sound, Out Skerries Harbour, &c.

—— *bispinosus,* Bate. St. Magnus Bay, in 50 fathoms.

—— *macer,* n. sp. Pleon having the posterior margin of the first five segments serrated right across the back, with a larger central hastate tooth, which increases in size from the first to the fourth segment, where it attains its greatest development. All the members of the body unusually long and slender; pereiopods excessively long and delicate; basos of posterior pairs narrow; meros and carpus both very long, the former the longer, and both longer than the long propodos; nail very slender (half as long as propodos), with a single seta beyond the middle of the inner margin. Uropods very long, the last pair with peduncle and rami subequal, the whole organ as long as four segments of pleon (*i. e.* third to sixth). First gnathopods the longer, second the stouter; in both pairs the hand shorter than wrist, and the palm undefined. Telson deeply sulcated. Length a quarter of an inch. St. Magnus Bay, muddy bottom, 60 fathoms, 1867. The eye in this species is situated unusually low down and opposite the base of the inferior antennæ; the antennæ are broken off in my specimens. The slenderness of the *anterior* pereiopods is very remarkable.

Pherusa bicuspis (Kröyer). *Amphithoë bicuspis,* Kröyer, Grönlands Amphip. p. 273, pl. ii. fig. 10. Balta Sound, 5 fathoms; and Bressay Sound, 3–7 fathoms.

—— *fucicola,* Leach. Out Skerries Harbour, 3–5 fathoms, 1861.

Calliopius Ossiani (Bate). One mile north of Whalsey Lighthouse, 40 fa-

thoms; forty miles east of Whalsey Skerries, 70–90 fathoms. The name *Calliope* being preoccupied, Lilljeborg has changed the title of this genus to *Calliopius*.

Calliopius Fingalli (Bate & Westw.). The type specimen found in 1861.

Eusirus Helvetiæ, Bate=*Eusirus bidens*, Heller, Amphip. des adriatischen Meeres, p. 32, pl. iii. fig. 19. Five to eight miles east of Balta, in 40–50 fathoms, sand, 1867. Thighs of last three pereiopods strongly serrated behind; first two segments of pleon dorsally produced into a central tooth; hinder margin of third segment of pleon serrated on the side, lower serrations directed upwards, upper serrations directed downwards; all the uropods subequal in length; telson reaching to the middle of the rami of the last pair.

Leucothoë furina (Savigny). St. Magnus Bay and Balta Sound.

—— *articulosa* (Montagu). In branchial sac and water-passages of *Ascidia mentula* and *A. venosa*. This species and *Anonyx tumidus* are the two Amphipoda which, with a number of Copepoda, constitute the crustacean parasites of the *Ascidiadæ*.

Gossea microdeutopa, Bate. Found in 1861; the exact habitat forgotten.

Aora gracilis, Bate=*Autonoë punctata*, Bruzelius, Skand. Amphip. Gammarid. p. 24, pl. i. fig. 3. Common in shallow water in all the Voes, among Laminariæ. The female differs widely from the male in the structure of the first gnathopods. In these organs the meros is not abnormal (as in male), the wrist subquadrate, slightly widening distally, posteriorly fringed with setæ, and a tuft of setæ on the side; propodos broadly ovate, with tufts of setæ on both margins; palm undefined, except by the presence of a spine with which the finger when closed impinges; finger strong, half length of hand, serrate on the inner margin, with a small cilium in each serration. I *believe*, judging from specimens named for me by Mr. Bate, and the figure and description which represent an animal "sparingly scattered with black dots," that the *Microdeuteropus anomalus* of Bate and Westwood, p. 293 (*not of Rathke*), is the female of this species; but the females of this and of the next species are so very much alike as to be almost undistinguishable.

Microdeuteropus anomalus (Rathke). *Gammarus anomalus*, Nova Acta Leop. 1843, p. 63, pl. iv. fig. 7, =*Autonoë anomala*, Bruzelius, Skand. Amphip. Gammarid. p. 25, pl. i. fig. 4 (but scarcely *Microdeutopus anomalus*, Bate & Westwood, Brit. Sessile-eyed Crust. p. 289), =*Microdeutopus gryllotalpa*, Bate & Westwood, *l. c.* p. 289 (but not of Costa).

The figure in the 'Brit. Sessile-eyed Crustacea' of *Microdeutopus gryllotalpa* represents the young male of this species; in the adult male the strong tooth-like process of the carpus of the first gnathopods is itself furnished with a secondary (lateral) tooth; and the hand is much narrower at the base than at the apex, the posterior margin being concave; this state is well represented by Bruzelius, pl. i. fig. 4, *d*. The female is extremely like that of the last species, and is sufficiently well represented at p. 293, Brit. Sessile-eyed Crust.; though, for reasons already stated, I incline to think that that figure really is drawn from the female of *Aora*. This species is most certainly not the *Microdeutopus gryllotalpa* of Costa (Ricerche sui Crostacei Amfip. del regno di Napoli, p. 231, pl. iv. fig. 10), which, from the four teeth of the carpus, seems to be closely allied to, if not identical with the *Autonoë grandimana* of Bruzelius. Dredged in 70–90 fathoms, about forty miles east of the Out Skerries, 1861.

Microdeuteropus versiculatus, Bate. The figures given of this species represent the female. The male differs greatly in the structure of the first gnathopods; these have the carpus very large, ovate, and very broad, infero-posteally produced into a simple tooth-like process, which reaches forward to not quite half the length of the hand; hand as wide or wider at the extremity than at the base; posterior margin convex, undulated; finger internally serrated, serrations very few, three to five only. Rare in Shetland; 70–80 fathoms, Outer Haaf.

—— *Websteri*, Bate. Bate and Westwood's figure represents the male. Specimens from Bressay Sound have a deep brown broad band across the pereion; and in company with them were other specimens similarly marked, and agreeing in general characters, but with gnathopods of totally different structure. These I take to be the females. They so closely resemble the females of *Aora gracilis* and *Microdeuteropus anomalus* that one description would suffice for all. Also taken among Laminariæ in St. Magnus Bay and on the Haaf. I question whether there are sufficient grounds for separating the genus *Aora* from *Microdeuteropus*. We have seen that the females of two are almost undistinguishable; and if *Aora* be divided from *Microdeuteropus* because the tooth-like projection proceeds from the meros and not the carpus, *M. Websterii* must in justice have a similar distinction conferred upon it, because in that species the tooth-like projection does not spring from either meros or carpus, but from the hand.

Genus Megamphopus, n. g.*

Antennæ slender (imperfect), the insertion of the lower so much behind that of the upper that the end of the third joint of the peduncle is only on a level with the end of the head. First segment of pereion produced forwards and downwards on each side into a remarkable horn-shaped process. Both pair of gnathopods greatly developed, of equal size, and subchelate. First three pereiopods short, last two much longer. Telson tubular.

Megamphopus cornutus, n. sp. (species typica). Head produced greatly beyond the origin of the inferior antennæ; eye round, black, immediately behind the base of the superior antennæ, and thus greatly in advance of the origin of inferior antennæ. Superior antennæ slender, first joint very much thicker than but only about half the length of second, subequal in length to last; (there is perhaps a *very minute* secondary appendage, one-jointed, not half length of first joint of filament; but as the filaments of the antennæ are imperfect, I cannot speak with certainty on the point, all I am confident of is that if there is a secondary appendage it is excessively minute). Inferior antennæ with the distal extremity of the third joint only reaching the extremity of the head; fourth joint twice as long as third, and last joint rather longer than fourth; filament subequal in length to last joint of peduncle, composed of eight long articulations. First segment of pereion produced forward and downwards into a curious horn-like process, the form of the side of the segment and its process reminding one strongly of the side of a wheelbarrow and its handle. First gnathopods greatly developed; basos long and slender, two following joints short; carpus long, nearly four times as long as broad, anterior margin straight, naked, posterior margin gently convex, with little tufts of setæ, distally produced into a short blunt process which curves backwards; propodos

* Μέγας, great; ἄμφω, both; πούς, a foot.

not quite so long as carpus, ovate; palm continuous with the hand, with a row of about eight strong spines; finger gently curved, shutting closely against the hand, which it nearly equals in length. Second gnathopods in general character very like the first, but the propodos somewhat broader and longer (as long as carpus), with two or three longitudinal rows of hairs in place of the spines of the first pair, and the finger only about half its length. Basos of the anterior pairs of perciopods of somewhat twisted form, the front margin armed with several (5–6) strong spines. All the uropods subequal in length, bearing the same general characters as in the genus *Microdeuteropus*. Telson tubular. Length a third of an inch. A single specimen procured in 1863.

Protomedeia pectinata, n. sp. Superior antennæ with second joint of peduncle subequal in length to but much more slender than first, last joint two-thirds length of second; filament slightly longer than peduncle, consisting of about ten long articulations; secondary appendage two-jointed, scarcely longer than first articulation of filament. Inferior antennæ subpediform, short; filament not longer than last joint of peduncle. First gnathopods having basos fringed anteriorly with a few scattered long setæ; ischium having a postero-distal dense tuft of long setæ; meros, carpus, and propodos all posteriorly thickly clothed with rather long setæ, the last two subequal in length, the propodos oblong, subparallel sided, twice as long as broad, distally truncate; finger strong, much longer than the truncated extremity of propodos, not internally serrate (as in ♀ of *Microdeuteropus versiculatus*, which this species resembles in general structure of first gnathopods), but furnished with a single large spine on the inner edge near the apex. Second gnathopods having basos long (equal in length to four succeeding joints), posteriorly straight, anteriorly convex, and furnished with two rows (one on edge and the other a little within it) of very long slender setæ, arranged in a comb-like manner; ischium and meros narrower than carpus; carpus narrow, only slightly widening distally; propodos subequal in length to carpus, lanceolate, tapering from base to distal extremity, both margins fringed with long setæ, those of the anterior side the longer; finger long, narrow, of equal thickness throughout, more than half as long as propodos, not unguiculate, nor capable of being bent back upon the propodos; the blunt distal extremity terminated by two or three setæ. First perciopods not having the meros anteriorly produced; finger very long and slender, subequal to propodos, and much longer than carpus. Last perciopods with hinder margin of basos not serrated, furnished with a row of distant setæ, which take their origin from some little distance within the margin. Telson and uropods closely resembling in structure those of the species of *Microdeuteropus*.

A single specimen (a female?) dredged in St. Magnus Bay, 1867.

—— (?) *Whitei*, Bate. Five to eight miles off the island of Balta, 40–50 fathoms, and in Balta Sound, about 7 fathoms.

This species is certainly no *Protomedeia*; the squamate, double telson separates it from that genus. I believe it to be the female of *Lilljeborgia Shetlandica*; at any rate the male of the present species most closely resembles the drawing and description of that species in all respects except that the basos of the last perciopods is not so distinctly serrated as figured. Unfortunately my type specimens of *Lilljeborgia Shetlandica* have been mislaid; and for the present it will be better to

keep the species apart, notwithstanding a very strong suspicion that they will hereafter prove to be the same.

Protomedeia hirsutimana, Bate. Unst Haaf, 90–100 fathoms, and 5–8 miles east of Balta, 40–50 fathoms. The posterior portion of the body, unknown to Mr. Bate, has some very remarkable characters. The last three pereiopods successively increase in length, the apex of the palm is truncate, the finger is short, strong, and bifid, and takes its origin from one-half only of the end of the propodos, while from the other half spring several long, spine-like setæ. First and second uropods subequal in length; the first with the branches furnished with the usually formed spines; the second of most unusual and remarkable character, excessively strong and massive, the branches furnished on their upper edge with two rows of immensely strong, but very short, stout, blunt spines; last uropods shorter than preceding pairs; branches subequal to peduncle, each bearing about three strong spines and terminating in a tuft of setæ. Telson tubular.

The extraordinarily massive and immensely strong spined second uropods have no parallel, as far as I am aware, among the known species of Amphipoda.

Bathyporeia pilosa, Lindström. Forty miles east of Out Skerries, 70–90 fathoms; 5–8 miles east of Balta, 40–50 fathoms; Balta Sound, 5–7 fathoms.

—— *Robertsoni*, Bate. "Two specimens have been dredged by our friend Mr. J. Gwyn Jeffreys in the Shetlands" (Bate and Westwood).

Melita obtusata (Montagu) = *Melita proxima*, Bate & Westw. Brit. Sessile-eyed Crust. p. 344 (the more common variety of male), = *Megamæra Alderi*, Bate & Westwood, p. 407 (the female). St. Magnus Bay, off Balta, Outer Haaf, &c.

Melita proxima is the common form of the male, and *Megamæra Alderi* is the female. The variety of the male with a central dorsal tooth on the second and third segments of pleon is far less common, and is the typical *Melita obtusata* (Mont.); one specimen of this variety has occurred to me in Shetland, and other specimens show scarcely visible rudimentary teeth on those segments.

Mæra longimana (Leach) = *Megamæra longimana*, Bate & Westw., the male = *Megamæra othonis*, Bate & Westw., the female. St. Magnus Bay, both sexes.

—— *brevicaudata* (Bate) = *Megamæra brevicaudata*, B. & W. A specimen determined by Mr. Bate, dredged in 4 fathoms, Bressay Sound, 1861.

Eurystheus erythrophthalmus (Lilljeborg). 5–8 miles off Balta, 40–50 fathoms.

Amathilla Sabini (Leach). Tide-pools, frequent.

Gammarus marinus, Leach. Between tide-marks.

—— *campylops*, Leach. "Our friend the late Mr. Barlee sent us some from the Shetlands" (Bate and Westwood).

—— *locusta*, Linn.

—— *pulex*, Linn.

Heiscladus longicaudatus, B. & W. The type specimens were taken in 1861, in 2–5 fathoms, Out Skerries Harbour; also St. Magnus Bay, and Balta and Bressay Sounds.

Amphithoë rubricata (Montagu).

—— *littorina*, Bate.

—— *albomaculata*, Kröyer. The only known British specimen, dredged in 1861, sixty miles east of Shetland, in 70–90 fathoms.

Sunamphithoë hamulus, Bate. Out Skerries Harbour, 2–5 fathoms, 1861; Hillswick, among Laminariæ, 1867.

—— *conformata*, Bate. "Sent to us by the late Mr. Barlee, who took it off the Shetlands" (B. & W.).

Podocerus pulchellus (Leach). Among *Tubularia indivisa*, in the caves of Burrafirth; and among Laminariæ at Hillswick.

—— *variegatus*, Leach. One mile north of Whalsey Lighthouse, in 40 fathoms; and in the Burrafirth caves.

—— *capillatus*, Rathke. Among *Tubularia indivisa*, in Halse Hellyer, Burrafirth; among Laminariæ, Hillswick; Out Skerries Harbour, 3–5 fathoms; and one mile north of Whalsey Lighthouse, in 40 fathoms.

I question whether B. and W.'s figure of the entire animal represents, as they suppose, the immature state of this *Podocerus*; but the figures of the gnathopod and superior antennæ illustrate the strongly marked features of the mature *P. capillatus.*

—— *falcatus* (Montagu). Out Skerries Harbour, 3–5 fathoms; Burrafirth caves; Bressay and Balta Sounds.

—— *pelagicus* (Leach). With the last, of which I believe it to be the female. I have never met with a male *pelagicus*, nor a female *falcatus*. The two forms occur in company, and the structural differences seem confined to the exact form of the hand of the gnathopods, organs which seem generally to differ among the Amphipoda according to the sex.

Cerapus abditus, Templeton. Balta Sound and Hillswick.

—— *difformis* (M.-Edwards) ♂,=*Dercothoë punctatus*, M.-Edwards, ♀. Vidlom Voe; off Balta and St. Magnus Bay. *Dercothoë punctatus* is unquestionably the female of *C. difformis*, not of *C. abditus*. The form which B. and W. figure as the female of *C. difformis* is probably a variety of the male.

Siphonœcetes typicus, Kröyer. The first British specimen, dredged in 1861, sixty miles east of Shetland, in 70–90 fathoms; also 5–8 miles east of Balta, 40–50 fathoms, 1867.

Nænia rimapalmata, Bate. St. Magnus Bay, and 5–8 miles east of Balta; 40 miles east of Whalsey Lighthouse, 70–90 fathoms.

—— *excavata*, Bate. Off Balta, and in St. Magnus Bay.

Cyrtophium armatum, n. sp. Body strongly tuberculated; head with a central tubercle; first segment of percion with two tubercles, one behind the other, all the remaining segments of pereion and first two of pleon having a transversely placed pair of tubercles, one on each side of the back, the tubercles of the last segment of pereion and of the first two of pleon much larger than the others. First gnathopods with wrist and hand subequal in length, the former wider at the base than at the distal extremity, with many setæ on sides and posterior margin, but none on the anterior margin; the latter subtriangular, widest in the middle (at the commencement of the palm), sloping thence equally to the base and to the origin of the finger, anterior margin gently convex, dorsal margin, sides, and palm bearing many setæ; finger not quite as long as the palm, strong, with a slightly bifid extremity. Second gnathopods with basos antero-distally produced into a strong spine-formed process; ischium, meros, and carpus all very short, and subequal in length, the meros on the posterior side running out into a very large spine-formed lobe; hand very large, obovate, very broad; palm half its length, bearing a few small setæ; finger very large and strong, well arched, inner margin simple. Pereiopods with the basos not at all expanded, nor wider than

the following joints; nails strong, scimitar-shaped, the entire limbs almost naked (having only a very few short setæ upon them). Length one-fifth of an inch. A single female dredged in 100–110 fathoms, twenty-five miles N. by W. from Burrafirth Lighthouse, in 1867. The specimen is imperfect, having lost antennæ, &c. The sixth and seventh segments of the percion appear to be coalesced. It approaches *Lætmatophilus tuberculatus* of Bruzelius, but is much more strongly tuberculated, and the gnathopods of different structure, the first smaller, the second larger, the hand broader, and the basos spined.

Unciola planipes, Norman, Nat. Hist. Trans. of Northumberland and Durham, vol. i. (1865) p. 14, pl. vii. figs. 9–13. Balta Sound, 5–7 fathoms. Many specimens.

Corophium longicorne (Fabricius). "Some specimens, which we take to be the young of this species, we find in the collection sent to us by the Rev. A. M. Norman, taken in from two to five fathoms, in Outer Skerries Harbour, Shetlands" (B. and W.).

—— *crassicorne*, Bruzelius, *the male*, = *Corophium Bonellii*, Bate & Westw. Brit. Sessile-eyed Crust. vol. i. p. 497 (? *Corophium Bonellii*, M.-Edwards), *the female*. Very abundant, in 2–5 fathoms, Out Skerries Harbour. The *C. Bonellii* of Bate and Westwood is unquestionably the female of *C. crassicorne*; the female of *C. longicorne* (which B. and W. thought *C. Bonellii* might be) is quite different.

—— *tenuicorne*, n. sp. Two females, dredged in St. Magnus Bay, resembling in general characters the same sex of *longicorne* and *crassicorne*, but distinguished as follows. Superior antennæ slender, longer than the inferior; first joint cylindrical (not expanded), peduncle with two or three spines on inner edge; second joint longer than first, slender, third not half as long as second; filament composed of six long joints, the terminal one bearing a number of long tentaculiform setæ. Inferior antennæ with penultimate joint of peduncle cylindrical (not expanded), inner edge with two or three articulated spines about the centre, and a single long, slender, articulated spine at the distal termination; last joint about two-thirds as long as the penultimate, bearing two spines on the middle of the inner side; filament unusually pediform, consisting of a long, stout articulation (more than half as long as the last joint of the peduncle) and a strong terminal nail. Finger of gnathopods bidentate at the apex. Nail of pereiopods longer than carpus and propodos combined. First and second uropods terminating in long slender spines, which are more than half as long as their rami; last uropods having the branch longer than its peduncle, not wide, three times as long as broad, tipped with long setæ, but having no setæ on the inner and outer margins. Length about one-fifth of an inch. The specimens procured are females laden with eggs; the male is unknown to me.

Hyperia galba (Montagu), Bate & West. Brit. Sessile-eyed Crust. vol. ii. p. 12, *the female*, = *Lestrigonus Kinahani*, Bate & Westw. *l. c.* p. 8, *the male*, =? *Lestrigonus exulans*, *l. c.* p. 5, *the young male*, =? *Hyperia medusarum*, Bate, Cat. Amphip. Crust. Brit. Mus. p. 295, pl. xlix. fig. 1, *the young female* (but not *Metoëcus medusarum*, Kröyer). In *Aurelia*, open sea, twenty-five miles N. by W. of Unst.

I believe that the above four so-called species are the different sexes and periods of growth of one. The specific points will be found in the structure of the gnathopods (as accurately described by B. and W. under *Lestrigonus exulans*) and of the uropods, which have the rami of all three

pairs wide in the middle but narrowed at the base, and mucronate at the terminations; the inner margins of the rami of the first pair, and the inner margin of the outer ramus, and both margins of the inner ramus of the last two pairs, are elegantly serrated.

Hyperia oblivia, Kröyer, Grönlands Amphipoder, p. 298, pl. iv. fig. 19 (but not *H. oblivia*, Bate & Westw. vol. ii. p. 16). Filaments of both antennæ consisting of only a single joint. First gnathopods with wrist and hand subequal, the former spined posteriorly, not at all produced distally; hand slightly tapering, palm serrate distally, finger two-thirds as long as hand. Second gnathopods with meros sheath-formed, tipped with spine-like setæ and overlapping carpus; carpus greatly produced distally into a lobe which reaches nearly to the extremity of the hand; finger straight, two-thirds as long as hand. Pereiopoda, last three pair much longer and more slender than in *H. galba*; carpus and propodos both very long, the latter the longer, both with small distant spines on the hinder margin, and the whole hinder edge of the propodos microscopically pectinate. Rami of all the uropods lanceolate (not widening in the middle), gradually tapering to the end (not mucronate as in *H. galba*); the general serrated character of the margins of the rami agrees with *H. galba*, except that the external margin of the inner ramus of the second pair is not serrated. The male differs from the female, as in the last two species, in having the antennæ very long and slender.

A female from an *Aurelia*, and males taken living free in the towing-net. It has also been sent to me by Mr. Edward from Banff; and Mr. G. S. Brady has procured both sexes in some numbers off the mouth of the Tees in the towing-net.

Bate and Westwood's "*H. oblivia*," which has not the propodos of the gnathopods at all produced, cannot be Kröyer's species nor that here described*. Göes takes Kröyer's *Lestrigonus exulans* to be the male of *H. oblivia*; and as far as the description and figures go, it may be the male either of that or of *H. galba*; but the short pereiopoda of *L. exulans* and *L. Kinahani* of Bate will not agree with the male of *H. oblivia*.

Metoëcus medusarum, Kröyer, Grönlands Amphip. p. 288, pl. iii. fig. 15 (not *Hyperia medusarum*, Bate, Cat. Amphip. Crust. Brit. Mus. p. 295). Female antennæ very short; filaments of both pair one-jointed. Both gnathopods nearly alike, short, distinctly chelate, and of peculiar structure; meros produced into a large sleeve-shaped process, postero-distally tipped with setæ, which fits round the basal portion of the carpus; carpus postero-distally produced into a large lobe, which extends as far as the extremity of the propodos, with which and with the finger it forms a regular chelate organ; propodos slightly tapering from the base to the extremity; its inner margin, the inner margin of the small finger, and the inner margin of the thumb-used lobe of the carpus all denticulately serrated; hand and wrist wholly free from hairs or spines. Pereiopods of moderate length; carpus and propodos subequal, their inner margins microscopically pectinate. All the uropods having the inner margin of outer ramus, and both margins of inner ramus serrated. The male differs from the female in having very long antennæ.

A female found in a *Medusa* in Shetland in 1867; and a male has been sent to me by Mr. T. Edward from Banff.

The *Hyperia medusarum* of Bate bears no resemblance to Kröyer's

* I would propose for it the name of *H. gracilipes*.

species, to which it is referred, the gnathopods being of entirely different structure.

Phronima sedentaria (Forskaal). "The only specimen of this species which we have seen as a native of the British coast is one in the British Museum, taken by Dr. Fleming on the 3rd of November, 1809, at Burray, in Zetland, amongst rejectamenta of the sea. Other specimens from the Shetland Islands were obtained by the late Dr. Johnston, and exhibited by him before the Berwickshire Naturalists' Club in 1855.—Proceedings, vol. iii. p. 212." (B. and W.)

Dulichia porrecta, Bate. St. Magnus Bay, 40–60 fathoms.

Proto pedata (Abildgaard). Out Skerries Harbour, 2–5 fathoms; Bressay Sound, among Laminariæ; St. Magnus Bay, very abundant, 40–60 fathoms.

—— *Goodseri*, Bate. Out Skerries Harbour and St. Magnus Bay; much scarcer than the last.

Caprella linearis (Linn.). Very abundant in Halse Hellyer, Burrafirth, among *Tubularia indivisa* and sponges.

—— *lobata* (Müller). With the last, but scarce.

—— *hystrix*, Kröyer. Caves at Burrafirth, 1863.

Order ISOPODA.

Tanais Dulongii, B. & W. St. Magnus Bay, rare.

Paratanais rigidus, Bate & Westw. St. Magnus Bay, 1867.

Anceus maxillaris (Montagu). Frequent.

—— *Edwardii*, Bate. 15–20 fathoms; Vidlom Voe.

Phryxus abdominalis (Kröyer). On the abdomen of *Hippolyte Cranchii*, var. *pusiola*.

—— *longibranchiatus*, Bate & Westw. "Our specimens of this species were forwarded to us from Shetland by Mr. J. Gwyn Jeffreys" (B. and W.).

—— *Galatheæ* (Hesse). Under carapace of *Galathea dispersa*.

Æga monophthalma, Johnston. One fine specimen procured in 1861.

Cirolana spinipes, Bate & Westw. Haddock ground, near Whalsey Skerries, and in St. Magnus Bay; not uncommon.

—— *truncata*, n. sp. Head much wider than long; greatest width in the centre, at the projection of the eyes, narrower behind and in front, which is slightly tridentate. Superior antennæ suddenly bent in a remarkable way at a right angle at the junction of first and second joints of the peduncle; third joint of peduncle much narrower and shorter than the second; filament consisting of only about four joints, the first twice as long as last joint of peduncle, and longer than the rest of the filament. Inferior antennæ very long and slender. Telson as broad as long; margins crenulated, distally truncate and denticulate; the two external teeth on each side larger than the intermediate ones. Last uropods having both branches truncate at the extremity.

Dredged in 40–60 fathoms, muddy bottom, in St. Magnus Bay, 1867.

Eurydice pulchra, Leach. St. Magnus Bay.

Jæra albifrons, Leach. Tide-marks, under stones, common.

Leptaspidia brevipes, Bate & Westwood. St. Magnus Bay, 40–60 fathoms; 5–8 miles east of Balta, 40–50 fathoms.

Janira maculosa, Leach. Frequent, between tide-marks, and dredged.

Limnoria lignorum (Rathke). In a piece of wood between tide-marks, near Lerwick, 1861.

Arcturus longicornis (Sowerby). Common.
—— *gracilis* (Goodsir). 5–8 miles off Balta, 40–50 fathoms.
Idotea tricuspidata, Desmarest.
Sphæroma Prideauxianum, Leach. A single specimen.
Cymodocea truncata (Montagu). Rare; Bressay Sound and St. Magnus Bay.
Ligia oceanica (Linn.).
Oniscus asellus, Linn.
Porcellio scaber, Latreille.

These are the only terrestrial Isopoda which I have noticed; doubtless several others occur, and only require to be looked for.

Order PHYLLOPODA.

Nebalia bipes (O. Fabr.). Balta Sound, 5–7 fathoms; 5–8 miles east of Balta, 40–50 fathoms; St. Magnus Bay.

Order CLADOCERA.

Daphnia pulex (Linn.).
—— *vetula*, Müller.
—— *reticulata* (Jurine).
Bosmina longirostris (Müller). Small lake near Lerwick.
Acantholeberis curvirostris (Müller). Common, mainland and Unst.
Ilyocryptus sordidus (Liévin). Pond back of Lerwick North Loch (Mr. D. Robertson).
Lynceus harpæ, Baird. Lake near Hillswick (A. M. N.); and near Scalloway (Mr. D. Robertson).
—— *elongatus* (G. O. Sars). Common.
—— *quadrangularis*, Müller. Common.
—— *exiguus*, Lilljeborg. Lake near Lerwick (A. M. N.); and near Scalloway (Mr. D. Robertson).
—— *trigonellus*, Müller. Lake near Hillswick.
—— *nanus* (Baird). Pond near Scalloway (Mr. D. Robertson).
—— *sphæricus*, Müller.
Eurycercus lamellatus (Müller).
Evadne Nordmanni, Lovén. Open sea, surface-net, common.
Pleopis polyphemoides, Leuckart. Less common than the last, and procured under similar circumstances.

Order OSTRACODA.

Cypris ovum (Jurine).
—— *compressa*, Baird.
Paracypris polita, G. O. Sars. St. Magnus Bay, 1867.
Pontocypris mytiloides (Norman). Abundant, living among Laminariæ, and down to 100 fathoms.
—— *hispida*, G. O. Sars, Oversigt af Norges marine Ostracoder, 1865, p. 16. Very like the last, smaller, and paler in colour, of a light fulvous hue; a little more produced behind, upper margin less prominent in front; ventral margin more concave; seen from above much more tumid, width fully equalling one-third of the length. Surface of valves clothed with close-set long hair; right valve having only five serrations at the infero-posterior angle. Sars also describes the animal as differing in having the nail of first feet very long and slender, exceeding in length the four preceding joints, and greatly curved at the extre-

mity; in the terminations of the postabdominal rami being of equal size, and the eye wholly absent. St. Magnus Bay, in 50 fathoms, 1867. Now first added to our fauna.

Pontocypris trigonella, G. O. Sars. Among Laminariæ, Balta and Bressay Sounds; St. Magnus Bay, 5–50 fathoms.

—— *acupunctata*, Brady. A fine living series from St. Magnus Bay, about 60 fathoms.

Bairdia inflata (Norman). St. Magnus Bay, and 5–8 miles off Isle of Balta, in about 50 fathoms, 1867.

—— *complanata*, Brady. 5–8 miles east of Balta, 40–50 fathoms.

Macrocypris minna (Baird). "Dredged in from 80–90 fathoms, sand, 20 miles east of the Noss in the Shetland Isles, R. M'Andrew, Esq." (Baird). The one specimen in my own collection was found by Mr. Waller in sand dredged on the Outer Haaf, in 1861.

Cythere lutea, Müller. Common, alive, rock-pools; dead, 60 fathoms.

—— *viridis*, Müller. Among Laminariæ, Balta Sound and Hillswick.

—— *pellucida*, Baird. Scarce; off Balta, 73 fathoms.

—— *tenera*, Brady. St. Magnus Bay, Outer Haaf, &c.

—— *convexa*, Baird. "Lerwick, Mr. Robertson" (Brady).

—— *albomaculata*, Baird. Alive, littoral and laminarian zones.

—— *tuberculata* (G. O. Sars). Very rare, Unst Haaf.

—— *concinna*, Jones (*Cythereis clavata*, Sars). St. Magnus Bay, 50–60 fathoms, 1867.

—— *angulata* (G. O. Sars). "Lerwick, Mr. D. Robertson" (G. S. Brady).

—— *dubia*, Brady. The type specimen was procured in sand from the Unst Haaf, dredged in 1863; also Unst Haaf, 100 fathoms, 1867.

—— *costata*, Brady, Trans. Zool. Soc. vol. v. p. 375, pl. lx. fig. 5. Two valves from the Unst Haaf, 1867, agreeing in every respect with the type specimens from the Hunde Islands. Now first added to the British fauna.

—— *villosa* (Sars). Lerwick and St. Magnus Bay.

—— *quadridentata*, Baird. 50–100 fathoms, off Island of Balta, and Out Skerries and Unst Haafs, also St. Magnus Bay.

—— *emaciata*, Brady. 80–100 fathoms, Unst Haaf, rare.

—— *mucronata* (Sars). The only British specimen, in 80–90 fathoms, 20 miles N. by W. from Burrafirth Lighthouse, 1863.

—— *antiquata* (Baird). Frequent in deep water down to 100 fathoms.

—— *Jonesii* (Baird). 50–100 fathoms, Out Skerries and Unst Haafs.

—— *acerosa*, Brady. St. Magnus Bay, in about 60 fathoms, and 5–8 miles east of Balta, in 40–50 fathoms.

—— *abyssicola* (G. O. Sars). *Cythereis abyssicola*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 43. "Lateral view of female elongated, subquadrate, much higher in front than behind, the greatest height somewhat greater than half the length; anterior extremity obliquely rounded, posterior truncate: dorsal margin very prominent and angulated over the eyes, in the middle slightly concave, then convex, and sloping towards the hinder extremity; ventral margin distinctly sinuated in the middle. Dorsal aspect of irregular form, showing on each side two somewhat prominent angulated protuberances, separated from each other by a deep sinus, both extremities a little projecting and truncate. Valves very hard, distinctly areolated in the middle, and girt with a broad and much-thickened margin, forming two lips, the innermost of which is finely toothed at each extremity, and beset with long hairs,

especially at the hinder extremity. Hinge-tooth of the left valve absent. Eyes very small, round. Colour pale brownish yellow, the limbs pale yellow. Antennæ rather long, third and fourth joints of the upper pair coalesced, the last joint short; lower pair with the third joint narrower than usual, and the terminal nails long. Branchial appendage of the palp of the mandibles very small, only bearing two setæ, one rudimentary and hamate. Legs slender, second joint of last pair subequal in length to the two succeeding, terminal nail very slender. Copulative organs of male small, the terminal part obtusely triangular." Unst Haaf, 20–25 miles N.N.W. of Burrafirth, 100–140 fathoms. Now first added to our fauna.

Cythere crenulata (G. O. Sars). *Cythereis crenulata*, G. O. Sars, Overs. af Norges mar. Ostrac. p. 39.

"Not unlike *C. emarginata*, but the shell much more ventricose, height and breadth subequal; side view very short, the height much exceeding half the length, obliquely rounded in front, behind subtruncate and slightly emarginate, the lower lobe the more prominant: dorsal margin a little concave behind the eyes, then convex; ventral margin nearly straight, or indistinctly waved in front of the middle. Dorsal view very tumid in the middle, the two extremities slightly prominent and subtruncate. Valves indistinctly areolated, but closely and finely punctate, the front margin and lower part of the hinder margin forming two lips, the innermost of which is crenulated with fine teeth, and fringed with rather long hair; surface uneven, a rounded protuberance before the middle, and two elongated protuberances towards the hinder extremity, one of which is near the dorsal, the other near the ventral margin. Eyes very large." Rare, 20–25 miles N.N.W. of Burrafirth, 100–140 fathoms. New to Britain.

—— *emarginata* (G. O. Sars). One young specimen (?) in St. Magnus Bay, about 60 fathoms.

—— *leioderma*, n. sp. Carapace very tumid, subquadrate, length to height as about two to one; greatest height anterior: dorsal margin nearly straight; ventral also nearly straight, slightly sinuated in the middle: anterior extremity subtruncately and subobliquely rounded, infero-anteal corner well rounded, commencement of anterior dorsal slope a little angled; posterior extremity truncate, not at all oblique, slightly emarginate in the middle. Valves smooth, not sculptured, having only a very few distant punctured papillæ. Dorsal view long-elliptic, very tumid; breadth equal to one-half of length, of nearly equal width throughout, and remarkably regularly rounded at the broad extremities. Length $\frac{1}{25}$ inch.

This species has much more the aspect of a *Cytheridea* than of a *Cythere*, but the hinge-margin is not toothed. In the genus *Cythere* it should perhaps come next to *C. albomaculata*.

From very deep water, Unst Haaf, 1867.

Cytheridea papillosa, Bosquet. Rare, Unst Haaf, 1867.

—— *punctillata*, Brady. Unst Haaf, 100 fathoms.

—— *subflavescens*, Brady. One specimen, 5–8 miles off Balta, 50 fathoms, 1867, exactly agreeing with the type; another in St. Magnus Bay.

—— *Sorbyana*, Jones. 80–100 fathoms, 20–25 miles N.N.W. from Burrafirth Lighthouse, 1867.

—— *Zetlandica*, Brady. The type specimens were found by me among a gathering of shells &c. procured by washing weeds in Shetland, by Mr. Barlee.

Eucythere declivis (Norman). Common in deep water, and very fine.
—— *Argus* (G. O. Sars). I am indebted to Mr. Robertson for specimens of this species, from off the Isle of Papa Stour, Scalloway.
Ilyobates Bartonensis (Jones). St. Magnus Bay, in about 50 fathoms, 1867; very local.
Loxoconcha impressa (Baird). Tide-marks, and among Laminariæ, living, Balta and Lerwick.
—— *tamarindus* (Jones) (*Cythere lævata*, Norman). Common in deep water down to 100 fathoms.
—— *guttata* (Norman). Common in deep water, especially in St. Magnus Bay, muddy ground.
Xestoleberis aurantia (Baird). Tide-marks, and among Laminariæ, Balta, &c.; also dredged.
—— *depressa*, G. O. Sars. Common in deep water, especially abundant in St. Magnus Bay, in about 50–60 fathoms.
Cytherura nigrescens (Baird). Tide-marks, and down to 50 fathoms.
—— *angulata*, Brady. "Lerwick, Mr. D. Robertson" (G. S. Brady).
—— *striata*, G. O. Sars. 3–60 fathoms, frequent.
—— *lineata*, Brady. St. Magnus Bay, 60 fathoms.
—— *cuneata*, Brady. "Lerwick, Mr. D. Robertson" (G. S. B.).
—— *similis*, G. O. Sars. "Shetland, Mr. D. Robertson" (G. S. B.).
—— *undata*, G. O. Sars. St. Magnus Bay, 30–60 fathoms.
—— *pumila*, Brady (MS.). Among Laminariæ, Bressay Sound, 1867. Not yet described.
—— *producta*, Brady. With the last.
—— *cornuta*, Brady. "Shetland, Mr. D. Robertson" (G. S. B.).
—— *acuticostata*, G. O. Sars. St. Magnus Bay, 50–60 fathoms, common.
—— *clathrata*, G. O. Sars. Ten miles east of Balta, in 73 fathoms, rare.
—— *cellulosa* (Norman). St. Magnus Bay, deep water; also ten miles east of Balta, 73 fathoms, and Bressay Sound, 5–7 fathoms.
—— *concentrica*, C. B. & R. (MS.). Some very small *Cytheruræ* procured among Laminariæ in 5–7 fathoms, Bressay Sound, are a species which will be described from fossil specimens in the forthcoming 'Monograph of the British Posttertiary Entomostraca,' by Messrs. Crosskey, Brady, and Robertson, to be published by the Palæontographical Society.
—— *flavescens*, Brady (MS.). One specimen, 20–25 miles N.N.W. of Burrafirth Lighthouse, 100–140 fathoms. Not yet described.
—— *quadrata*, n. sp. Carapace viewed laterally subquadrangular, of nearly equal height throughout; height more than half length; rounded in front, the dorsal arch the more gradually sloped; behind produced to a well-developed central process; ventral and dorsal margins straight, the former terminating behind in a right angle; surface-sculpture consisting of pittings more or less circular in shape, arranged for the most part in longitudinal rows; a small keel runs parallel with the ventral margin, and terminates in front in a triangular ala well pronounced but small in size. Length $\frac{1}{60}$ inch.

C. quadrata comes very near to *C. striata*, but is shorter and higher, the ventral margin quite straight; the ala is more developed, and the carapace more tumid.

St. Magnus Bay; also Plymouth.

—— *navicula*, n. sp. Carapace having dorsal margin perfectly straight in the central portion, then sloping both before and behind very obliquely, with a well-marked very obtuse angle; ventral margin also straight, the straight portion much longer than that of dorsal margin, with two

small nodulous processes, one just opposite the commencement of each dorsal slope, anteally scarcely rising at all to join the dorsal slope which at that extremity meets the ventral line very much below the centre; posteally sloping upwards obliquely, and meeting the dorsal margin at a rounded point a little below the middle of that extremity; surface perfectly smooth and glabrous. Ventral aspect boat-shaped, the resemblance most striking, centrally depressed at the juncture of the valves; bows moderately sharp, of good breadth of beam, sculptured with raised thread-like concentric lines representing the timbers, while the small nodulous processes (mentioned in describing the lateral view) will stand for the thole-pins; the dorsal and end views bear out the allusion, the former representing a boat viewed from below, with a well-marked keel, and the latter being triangular with gently rounded sides. Length about $\frac{1}{40}$ inch. St. Magnus Bay, 30–60 fathoms, 1867.

Genus SARSIELLA*, n. g.

Carapace subrotund, with a rostrate posterior (?) projection, much compressed; surface of valves very rough, with greatly elevated rib-like sculpture; ventral margin quite flat in its central portion.

These are certainly not satisfactory generic characters, being so incomplete, but having only one good specimen I am unwilling needlessly to run the risk of destroying it in the attempt to separate the valves, and therefore am unable to describe the hinge-structure or animal. The carapace is, however, so remarkable that I cannot place it in any described genus. It is the largest of British *Cytheridæ*.

Sarsiella capsula, n. sp. Carapace nearly circular, with a short rostriform process running out from the extremity; dorsal and ventral margins each nearly semicircular; anterior margin completely and widely rounded; posterior with a rostrate process below the middle, the ventral margin rather angled in its upward slope, but the dorsal perfectly rounded. Surface of valves extraordinarily rugose, with concentric greatly elevated carinæ enclosing a deep hollow in the centre of the valves, and on their exterior side having numerous radiating ribs passing off in all directions to the margin; interstices of these ribs and inner slopes of carinæ sculptured with circular pittings. Ventral aspect very irregular, in the centre a quadrangular flat portion sculptured with circular pittings. Anterior portion with tuberculately convex gradually approximating sides; posterior portion consisting of the rostriform process, which is seen projecting beyond the truncate extremity of the quadrangular portion. End view with flat sides dorsally arched, ventrally truncate. The valves are very much compressed, though appearing more tumid than they really are, on account of the great elevation of the sculptured surface. Length about $\frac{1}{15}$ inch. St. Magnus Bay, 30–60 fathoms.

Cytheropteron latissimum (Norman). St. Magnus Bay, and 10 miles east of Balta, 30–73 fathoms.

—— *nodosum*, Brady. In the same localities as the last.

—— *punctatum*, Brady. 10 miles east of the Island of Balta, in 73 fathoms.

* Named after Herr G. O. Sars. A genus *Sarsia* is already established in honour of the father, Professor Sars. I have given this genus a diminutive termination in reference to the son, one of the ablest and most accurate of the younger naturalists of the day, whose admirable Monograph on the Scandinavian Marine Ostracoda points to a fitness in associating his name with that order.

Cytheropteron multiforum (Norman). Common, 30–140 fathoms.

—— *alatum*, G. O. Sars, Overs. af Norges mar. Ostrac. p. 81. "Lateral protuberance very large, triangular, slightly inclined downwards, and running out into a strong mucro, which projects at the sides; its hinder margin furnished with (about twelve) flattened teeth, the two innermost much larger than the rest, and in the form of quadrangular serrated laminæ. Lateral aspect of female elongated ovate, the greatest height, which is in the middle, much less than half the length, equally rounded in front, behind projecting into a very large process, which is obliquely truncate at the end; dorsal margin regularly arched, ventral slightly sinuated, the lateral protuberance projecting below in the centre of the ventral margin. Dorsal aspect almost cruciform, the greatest width (between the lateral protuberances) exceeding twice the height, and even somewhat surpassing the length, suddenly attenuated in front, and more gradually behind. The shell of the male scarcely differs from that of the female except in the smaller size. Valves white, pellucid, smooth, finely toothed on the front margin." A single specimen of this interesting addition to our fauna, in sand dredged 5–8 miles east of the Island of Balta, in 40–50 fathoms. The form is most remarkable, on account of the immense projection of the lateral alæ and their dentated edge.

—— *rectum*, Brady. The type was "dredged by Mr. D. Robertson, in Lerwick Bay, Shetland, in a depth of 12–14 fathoms" (G. S. Brady). I have procured a second specimen in St. Magnus Bay, in about 60 fathoms.

Bythocythere simplex (Norman). St. Magnus Bay, and 10 miles east of Balta, 50–73 fathoms.

—— *constricta*, G. O. Sars. Widely distributed in deep water to 100 fathoms.

—— *turgida*, G. O. Sars. St. Magnus Bay, and 10 miles off the Island of Balta, 50–73 fathoms.

—— *tenuissima*, n. sp. Elongated, doubly fusiform, both extremities acuminate, equally gradually attenuated to sharp central points; greatest height central; length to height as 3–4 to 1: dorsal margin gently convex throughout; ventral slightly flexuous, but slightly arched throughout the greater part of its length; both margins gradually approaching each other towards the extremities: valves very thin and fragile, their surface perfectly smooth and glabrous. Dorsal view remarkably compressed and greatly elongated, widest in the centre, and gradually becoming narrower (it is only possible for them to become in the slightest degree narrower) to the extremities. Length $\frac{1}{20}$ inch.

St. Magnus Bay, 30–60 fathoms. I place this species provisionally in the genus *Bythocythere*, as it seems more nearly related to *B. simplex* in general structure than to any other Ostracod. The lateral aspect of the carapace finds its nearest counterpart in *Bairdia angusta*, G. O. Sars; but whereas that species is tumid this is exceedingly compressed.

Pseudocythere caudata, G. O. Sars. 20–25 miles N.N.W. of Burrafirth, in 100–140 fathoms; 10 miles east of Balta, 50–73 fathoms; and St. Magnus Bay, 30–60 fathoms.

Sclerochilus contortus (Norman). Very common at all depths, 1–70 fathoms.

Paradoxostoma variabile (Baird). In extraordinary profusion on Laminariæ in Balta and Bressay Sounds; also Out Skerries and Hillswick.

—— *Normani*, Brady. Among Laminariæ, Bressay Sound, St. Magnus Bay, and 5–8 miles east of Balta, 5–50 fathoms, alive.

—— *abbreviatum*, G. O. Sars. St. Magnus Bay, 50 fathoms.

Paradoxostoma obliquum, G. O. Sars. "Shetland, Mr. D. Robertson" (G. S. Brady).

—— *ensiforme*, Brady. St. Magnus Bay and Bressay Sound, 5–50 fathoms.

—— *flexuosum*, Brady. St. Magnus Bay, abundant.

—— *arcuatum*, Brady. A few specimens, 50 fathoms, in St. Magnus Bay; also a much smaller form, closely allied to, but perhaps distinct from, this species, common on Laminariæ in Balta Sound; it is of a green colour.

Philomedes interpuncta (Baird)=*Philomedes longicornis*, Lilljeborg. Two or three specimens on the Unst Haaf.

Cypridina Norvegica, Baird, Proc. Zool. Soc. 1860, p. 200, pl. lxxi. fig. 4; G. O. Sars, Overs. af Norges mar. Ostrac. p. 104. I have pleasure in announcing this, the grandest of European Ostracoda, as a member of the British fauna, a single specimen having been procured on the Unst Haaf in 1867.

Cylindroleberis Mariæ (Baird). Unst and Skerries Haafs, and St. Magnus Bay.

Bradycinetus Brenda (Baird)=*Cypridina globosa*, Lilljeborg. "Dredged in 80–90 fathoms, sand, 20 miles east of the Noss, in the Shetland Isles, by R. M'Andrew, Esq." (Baird).

Conchoëcia obtusata, G. O. Sars. A single imperfect *Conchoëcia*, believed to belong to this species, was procured from sand dredged on the Unst Haaf, 20 miles N. by E. from Burrafirth, in 1863.

Polycope orbicularis, G. O. Sars. 5–8 miles E. of Balta, 20–25 miles N. of Burrafirth Lighthouse, and in St. Magnus Bay, 40–100 fathoms.

—— *dentata*, Brady. The type specimen was from 100 fathoms, about 20 miles N.W. by W. from Burrafirth.

Order COPEPODA.

Cyclops serrulatus, Fischer. This is the only Shetland species I have as yet determined, but I have seen others.

—— *nigricauda*, n. sp. Antennæ shorter than first segment of body, 21-jointed; joints very short, all except first and last two shorter than broad. Lower antennæ stout and strong, two-thirds as long as upper antennæ; third joint with a seta at distal extremity of hinder margin; fourth (last) joint terminating in six long setæ. Last feet 1-branched, well developed, with a strong seta on the middle of the outer margin, and two similar terminal setæ, one at each angle of the extremity, with a very delicate and minute seta in the middle between them. Caudal laminæ extremely long and slender, more than equal in length to three preceding segments, of a dark brown colour throughout the greater part of their length.

A marine species found among Laminariæ in Shetland, and also at Tobermory in the Isle of Mull, abundantly. The black colour of the basal portion of the caudal laminæ is a very useful characteristic by which to distinguish the species with a low-power lens when mixed in a mass with other Copepoda.

In the male the antennæ are only 17-jointed, and the caudal laminæ shorter, about equal in length to the two preceding segments.

—— *pallidus*, n. sp. Upper antennæ shorter than first segment of body, 11- or 12-jointed (the basal joints not very distinct); last two joints longer than broad, last joint but two broader than long, two joints preceding this long, rest shorter. Caudal laminæ scarcely twice as long as broad, and shorter than the preceding segment.

Another marine species found among weeds at Hillswick, Shetland, and also at Tobermory in the Isle of Mull. A much smaller species than the last, and, if it were not for the greater number of joints in the antennæ, not unlike *C. magniceps* of Lilljeborg.

Longipedia coronata, Claus, Die frei lebenden Copepoden, p. 111, pl. xiv. figs. 14–24. Abundant at Hillswick.

Amymone falcata, n. sp. Superior antennæ in female 8-jointed; second joint the longest, fourth shorter than any of preceding; in male second and fourth joints subequal, and twice as long as third. First segment inferiorly much produced, and extending backwards in an acute falcate form. Hand long ovate, palm fringed with long cilia; finger nearly as long as palm, very slender. The coalesced sixth segment has the infero-posteal corner produced backwards into a somewhat hamate spine-formed process. Pereiopods long and slender, extending beyond the body.

In most particulars this species comes near to *A. sphærica*, Claus; but the first segment is widely different, being of similar form to that of *A. harpacticoides*, Claus, but still more produced.

Among Laminariæ, Bressay Sound, 1867.

Tisbe furcata (Baird) = *Canthocamptus furcatus*, Baird, Nat. Hist. Brit. Entom. p. 210, pl. xxv. figs. 1, 2, and pl. xxx. figs. 4–6, = *Tisbe furcata*, Lilljeborg, De Crust. Clad. Ostrac. et Cop. in Scaniâ occurr. p. 192, pl. xxv. figs. 1–5, 11, 12, and 17; Claus, Die frei lebend. Copep. p. 116, pl. xv. figs. 1–10, = *Tisbe ensifer*, Fischer, Beiträge zur Kenntniss der Entom. p. 24, pl. xxii. figs. 67–70. Common; Lerwick, Balta, Hillswick.

Westwoodia nobilis (Baird) = *Arpacticus nobilis*, Baird, *l. c.* p. 214, pl. xxviii. fig. 2, = *Westwoodia nobilis*, Claus, *l. c.* p. 118, pl. xxi. figs. 1–9. Among weeds at Lerwick, 1867.

Canthocamptus staphylinus (Jurine). Ponds, common.

Cleta forcipata, Claus, Die Copepoden-Fauna von Nizza (1866), p. 23, pl. ii. figs. 9–11. Between tide-marks, Balta Sound. The male differs from the female in the structure of the first feet, which are greatly longer, and at the same time more slender in all their parts. New to Britain.

Dactylopus Strömii (Baird) = *Canthocamptus Strömii*, Baird, Brit. Entom. p. 208, pl. xxvii. fig. 3, = *Dactylopus Strömii*, Claus, Frei lebend. Copep. p. 126, pl. xvi. figs. 1–6. Lerwick.

—— *tisboides*, Claus, Frei lebend. Copep. p. 127, pl. xvi. figs. 24–28; Die Copep.-Fauna von Nizza, p. 27, pl. iii. figs. 1–7. Bressay Sound.

Genus TIGRIOPUS*, n. g.

First feet having outer branches 2-jointed, both joints very long, last wide at the extremity, with short recurved claws; inner branch much shorter than the outer, 3-jointed; basal joint very long, two following short. Gnathopod (lower footjaw) of moderate size. Mandible palp 1-branched, 3-jointed.

Tigriopus Lilljeborgii, n. sp. = *Harpacticus chelifer*, Lilljeborg, De Crust. ex ord. tribus Clad. Ost. et Copep. p. 200, pl. xxii. figs. 2–11 (but not *Harpacticus chelifer* of other authors). Lilljeborg's figures of this species are good, and by comparing those of the gnathopod and first and last feet with the drawings given by Claus of the same parts of the true *Harpacticus chelifer*, the chief points of distinction will be at once manifest; the structure of the extremity of the outer branch of the first feet

* Τίγρις, a tiger; πούς, a foot.

reminds us strongly of the paw and claws of one of the Felidæ, hence the generic name which I have chosen. Frequent in Shetland, and sometimes occurring in immense numbers in rock-pools which are only reached by the sea at high spring-tides; under such circumstances I have taken it at the Out Skerries, Shetland, and near Marsden, on the coast of Durham. I have dedicated this species to that excellent carcinologist Professor Lilljeborg.

Thalestris longimana, Claus, Die frei lebend. Copep. p. 130, pl. xviii. figs. 1–11. Among Laminariæ, Bressay Sound.

—— *Helgolandica*, Claus, Die frei lebend. Copep. p. 131, pl. xvii. figs. 12–21. Bressay Sound.

—— *harpacticoides*, Claus, Die frei lebend. Copep. p. 133, pl. xix. figs. 2–11. Hillswick, among weeds, 1867.

—— *Clausii*, n. sp. Rostrum short, blunt, not as long as first joint of antennæ. Gnathopod (lower footjaw) having inner margin of hand straight, smooth, outer strongly arched; finger not quite as long as hand, much curved at the extremity. First feet with the branches shorter and stouter than usual, subequal in length; outer much stouter than inner, its inner margin glabrous, except three or four cilia close to the base, outer margin ciliate; a large lanceolate, ciliated spine on the peduncle; a spine at distal extremity of first, and another near the extremity of second joint, which is only about twice and a half as long as broad; last joint with three terminal spines and a seta, the innermost spine more slender than and about half as long again as the next: inner branch much more slender than outer, 2-jointed; first joint long, margins glabrous, inner with a seta rather nearer to the base than to the extremity; second joint terminating in two claw-spines, not very unequal in length. Last feet with the outer branch obovate, margin ciliated, with six setæ on the more distal portion of the outer margin and the extremity; the innermost seta the longest, and the two following close together, and very much smaller than the others: inner branch rather shorter than outer, five setæ on distal portion of inner margin and at the extremity, ciliated between the setæ, and the seta nearest the base plumose; the setæ not differing greatly in length, but the third rather the longest. Caudal laminæ with five setæ, which are peculiarly swollen at the base; the innermost but one the longest, the next half its length, the others very short, spine-like. In the male the abdominal segments have rows of spinules on the sides; the external branch of the last feet is narrow, with seven setæ, of which the innermost but one is much the longest, and the next is minute; the caudal setæ are not swollen at the base. First feet as in the female. Found among Laminariæ in Bressay Sound, 1867; and also at Tobermory, in the Isle of Mull, in 1866. I have named this species after the author of the beautiful work, so often referred to here, on the free-living Copepoda.

Harpacticus chelifer (Müller). Bressay Sound.

Porcellidium dentatum, Claus, Beiträge zur Kenntniss der Entomostraken (1860), p. 8, pl. ii. figs. 19–22; Die frei lebenden Copepoden, p. 140, pl. xvii. figs. 2–5. Among weeds, Hillswick and Lerwick, abundant.

—— *fimbriatum*, Claus, Die frei lebenden Copepoden, p. 140, pl. xvii. fig. 1. Hillswick and Lerwick.

—— *subrotundum*, n. sp. Short, broad, nearly as broad as long; cephalothorax subtruncate in front; antennæ short, not reaching the sides of cephalothorax. Caudal laminæ as broad as long, truncated distally;

appendages of antepenultimate segment triangular, with small setæ on the external margin towards the extremity. On Laminariæ, Hillswick.

Differing from *P. dentatum* chiefly in the form of the plate attached to the antepenultimate segment, which in that species is as wide, or even wider, at the extremity than at the base, and denticulate, while in *P. subrotundum* it is triangular, narrowing from the base to the extremity, and only furnished with small setæ. It may be mentioned that though the size of this plate in proportion to the other appendages varies greatly according to age, the form is still preserved.

Alteutha bopyroides, Claus, Die frei lebenden Copepoden, p. 143, pl. xxii. figs. 10–17. Abundant in the drift-net, and by washing Laminariæ.

—— *purpurocincta*, Norman = *Peltidium purpureum*, White, Popular History of British Crustacea, p. 308, pl. xviii. fig. 4 (but not *Peltidium purpureum*, Philippi). This fine species, which it is necessary to re-name, is abundant on Laminariæ at Hillswick.

Zaus spinosus, Goodsir, Ann. Nat. Hist. vol. xvi. (1845) p. 326, pl. xi. figs. 1–8; Claus, Die frei lebend. Copep. p. 146, pl. xxii. fig. 5, and pl. xxiii. figs. 1–10. Among weeds, tide-marks, Balta Sound.

Aspidiscus, n. g.*

Body oval, depressed like that of *Zaus*. Upper antennæ 9-jointed, second and third joints long, last six short (in male third joint short, fourth, fifth, sixth long). Lower antennæ with the secondary branch slender. First feet with the inner branch 3-jointed, the first large and very stout, second and third very short, the last with two membranaceous appendages; outer branch not longer than basal joint of inner branch, 3-jointed, last joint furnished with spines and setæ. Last feet consisting of one falcate, 2-jointed branch.

Aspidiscus fasciatus, n. sp. Cephalothorax ovate, truncate behind; sides of segments produced backwards in curved points. Abdomen much narrower than cephalothorax. Caudal laminæ very small, caudal setæ very long. Upper antennæ in female 9-jointed, first joint short, second longer, with numerous setæ on anterior margin, third much longer than second, with a tuft of setæ at the distal extremity of anterior margin, fourth half length of third, last five joints short; in the male the third joint is shorter than the second, fourth twice as long as third, fifth half length of fourth, and shorter than sixth, last three short. First feet having the inner branch with a very massive basal joint, which is hollowed on the inner margin at the base, where there is a rounded lobe attached to the peduncle; beyond this excavation of the margin there is a long seta, second and third joints very short, combined, not so long as the curious appendages of the last, which consist of two laciniæ terminating in membranaceous expansions, as in the genus *Scutillidium* (*vide* Claus, Die Copepoden-Fauna von Nizza, pl. iv. fig. 15); outer branch 3-jointed, much more slender and not longer than the basal joint of inner, the third joint furnished on the side with delicate spines, and at the apex with setæ; basal joint with a plumose seta at the distal extremity of outer margin. Last feet 1-branched, falcate, consisting of two long joints; the last slightly bilobed on the inner margin, ciliated, rounded at the extremity, with only one short terminal seta. Colour pale, with a ruby-coloured fascia on the second and third, or second, third, and fourth segments of the cephalothorax.

* Ἀσπιδίσκος, a little shield.

Abundant on Laminariæ at Hillswick. It comes near to *Scutillidium*, Claus, differing chiefly in the first feet having the inner branch with second and third joints very short, and in the structure of the outer branch; and in the last feet consisting of only a single branch.

Cetochilus septentrionalis, Goodsir = *C. Helgolandicus*, Claus, Die frei lebenden Copepoden, p. 171, pl. xxvi. figs. 2–7. Abundant in the surface-net in the open sea.

Calanus Clausii, G. S. Brady, Nat. Hist. Trans. Northumberland and Durham, vol. i. (1865) p. 33, pl. i. figs. 1–11, 13. In surface-net off Out Skerries, 1861, and Balta Sound, 1867.

Dias longiremis, Lilljeborg, De Crust. ex ord. tribus Clad. Ost. et Cop. (1853) p. 181, pl. xxiv. figs. 1–13; Claus, Die frei lebenden Copepoden, p. 193, pl. xxxiii. figs. 6–14; G. S. Brady, Nat. Hist. Trans. Northumb. and Durham, vol. i. (1865) p. 35, pl. i. fig. 14, and pl. ii. figs. 11–18, = *Calanus Euchæta*, Lubbock, Ann. Nat. Hist. 2nd ser. vol. xx. (1857) p. 401, pl. x. figs. 1–6. Abundant in the towing-net.

Temora Finmarchica (Gunner). Towing-net, common.

Ichthyophorba hamata, Lilljeborg, De Crust. Clad. Ostrac. et Copep. p. 185, pl. xxi. figs. 1–5, 7–9, and pl. xxii. figs. 9–12, = *Ichthyophorba angustata*, Claus, *l. c.* p. 199, pl. xxxv. figs. 2, 10–12, = *I. hamata*, G. S. Brady, Nat. Hist. Trans. Northumb. and Durham, vol. i. (1865) p. 39, pl. i. fig. 17, and pl. iv. figs. 7–10, = *Diaptomus Bateanus*, Lubbock, Ann. Nat. Hist. 2nd ser. vol. xx. (1857) p. 404, pl. xi. figs. 1–3. In towing-net, frequent.

—— *denticornis*, Claus, *l. c.* p. 199, pl. xxxv. figs. 1, 3–9; G. S. Brady, Nat. Hist. Trans. Northumb. and Durham, vol. i. (1865) p. 40, pl. iv. figs. 1–6. Towing-net, open sea, occasional.

Diaptomus Westwoodii, Lubbock, Trans. Linn. Soc. vol. xxiv. p. 203, pl. xxxi. figs. 1–6. In lakes near Lerwick, and in Unst.

Anomalocera Patersonii, Templeton. Common in the surface-net.

Pontellina brevicornis, Lubbock, Ann. Nat. Hist. 2nd ser. vol. xx. (1857) p. 407, pl. xi. figs. 4–8. Taken once abundantly in the towing-net between the Fair Isle and Shetland in 1863.

Notodelphys ascidicola, Allmann; Baird, Brit. Entom. p. 238, pl. xxx. figs. 7, 8, = *N. Allmanni*, Thorell, Crust. som lefva a arter af slägtet Ascidia, p. 34, pls. i. and ii. fig. 1.

From the branchial sac and water-passages of *Ascidia venosa*. The specimens of this and all the following species of Crustacea parasitic in Ascidians have been kindly forwarded to me by Mr. Albany Hancock, who found them during his investigations into the anatomy and physiology of the Tunicata, when dissecting Shetland Ascidians, with which Mr. Jeffreys and myself had supplied him. All the seven following species are new to our fauna.

—— *cærulea*, Thorell, Crust. som lefva a arter af slägtet Ascidia, p. 37, pls. iii. and iv. fig. 4.

From the branchial sac and water-passages of *Ascidia parallelogramma* and *A. venosa*.

—— *prasina*, Thorell, Crust. som lefva a arter af slägtet Ascidia, p. 41, pl. v. fig. 7. From the water-passages and branchial sac of *Ascidia mentula*.

Doropygus auritus, Thorell, Crust. som lefva a arter af slägtet Ascid. p. 50, pls. vii. & viii. fig. 10. From the branchial sac and water-passages of *Ascidia mentula*.

Botachus cylindratus, Thorell, Crust. som lefva a arter af slägtet Ascidia,

p. 55, pl. ix. fig. 12. In the branchial sac and water-passages of *Ascidia mentula*.

Notopterophorus papilio, Hesse, Annales des Sciences Natur. Cinquième Série, Zoologie, vol. i. (1864) p. 338, pl. ii. figs. 1, 2, and vol. iii. (1865) p. 221. This most extraordinary species was found by Mr. Hancock in the branchial sac and water-passages of *Ascidia mentula*. It is a very interesting addition to our fauna.

Entorocola eruca, n. sp. Allied to *Entorocola fulgens*, Van Beneden (Recherches sur la Faune Littorale de Belgique, Crustacés (1861), p. 150, pl. xxvi.), but is apparently distinct. The feet have one branch stout, papillary, not furnished with any claw, the other much more slender, terminating in three minute curved spines. The fifth segment of the body has a cylindrical tubercular process on each side of the back. The abdomen is composed of two (? three) articulations, and terminates in a furca, the branches of which are shorter than broad, and are furnished with a spine at the tip.

Adhering to the intestine of *Ascidia intestinalis*. The type of the genus was found by Van Beneden in two species of *Aplidium*.

Lichomolgus forficula, Thorell, Krustaceer som lefva i arter af slägtet Ascidia, p. 73, pls. xii. & xiii. fig. 19. From the water-passages and branchial sac of *Ascidia mentula*.

Ascomyzon echinicola, n. sp. Form of body and of the several segments near to that of *A. Lilljeborgii* (*vide* Thorell, K. Vet. Akad. Hand. Bd. iii. No. 8 (1859), pl. xiv. fig. 21), but the last thoracic segment rather longer, and the caudal laminæ fully twice as long as broad, and longer than preceding segment. Upper antennæ much shorter than in that species, 20-jointed, the eleven basal joints excessively short, the remaining somewhat longer, but none of them (unless it be the seventeenth and eighteenth) as long as they are broad.

Parasitic upon *Echinus esculentus*, Linn.

Caligus rapax, M.-Edwards. Common on fish belonging to the family Gadidæ.

—— *curtus*, Müller = *C. Mülleri*, Baird, Brit. Entom. p. 271, pl. xxxii. figs. 4, 5. Common on Cod, Haddock, Ling, &c.

Lepeophtheirus Salmonis, Kröyer, Naturhistorisk Tidsskrift, 2 Bd. (1837) p. 13, (figured): 1 Bd. pl. vi. fig. 7, = *Lepeophtheirus Strömii*, Baird, Brit. Entom. p. 274, pl. xxxii. figs. 8, 9. From "Sea-Trout" taken in the loch near Burrafirth.

—— *Hippoglossi*, Kröyer. Not uncommon on *Hippoglossus vulgaris*.

Trebius caudatus, Kröyer. Common on Skate.

Nogagus Lütkeni, n. sp. Upper antennæ with both joints long, the first terminating in a bunch of lanceolate plumose setæ, the second somewhat clavate, three to four times as long as broad; anterior margin plain, posterior with a single spine just beyond the middle; extremity with a tuft of setæ. Cephalothorax much rounded, the posterior lateral processes strongly arched and incurved. Hinder antennæ with the hook long and slender, and the penultimate joint furnished with two very long setæ. Second gnathopods (maxillipeds) with three crenated nodulous processes on the palm. Genital segment subquadrate, rather longer than broad, the sides gently convex. Abdomen consisting of two segments and the caudal laminæ; the segments short and broad, the second as long again as the first, the two taken together not exceeding the breadth of the last; the caudal laminæ large, as long as the two pre-

ceding segments, terminating in four long plumose laciniæ and two small spines; inner margin of laminæ ciliated.

Kindly procured for me by Dr. Saxby, and found on a Skate. It is very distinct from all the described species known to me. I have named it after my friend Dr. Lütken, of Copenhagen, to whom, in conjunction with Prof. Steenstrup, we are indebted for one of the best monographs on the parasitic Copepoda.

Echthrogaleus coleoptratus (Guérin) = *Dinematura coleoptrata*, Guérin, Icon. Règ. Anim. Crust. pl. xxxv. fig. 6, = *Dinemoura alata*, Baird, Brit. Entom. p. 285, pl. xxxiii. figs. 6, 7, = *Echthrogaleus coleoptratus*, Steenstrup & Lütken, Havs Snyltekrebs og Lernæer (1861), p. 40, pl. viii. fig. 15. On a Shark.

Dinematura producta (Müller) = *Dinemoura Lamnæ*, Baird, Brit. Entom. p. 286, pl. xxxiii. fig. 8, = *Dinematura producta*, Steenstrup & Lütken, Havs Snyltekrebs og Lernæer, p. 34, pl. vii. fig. 13. With the last.

Pandarus bicolor, Leach. On Dogfish.

Chondracanthus Lophii, Johnston = *Lernertoma Lophii*, Baird. In the pouches of the Angler, *Lophius piscatorius*.

Brachiella rostrata, Kröyer, Naturhistorisk Tidsskrift, 1 Bd. (1837) p. 207, pl. ii. fig. 1, and Naturhist. Tidss. Tredie Række, vol. ii. (1864) p. 364, pl. xvii. fig. 8. On the Holibut, *Hippoglossus vulgaris*. New to Britain.

Anchorella uncinata (Müller). Common on various Gadidæ and other fish.

Order THORACICA.

Balanus porcatus, Da Costa. Common in deep water; but I have never seen large specimens in the Shetland seas.

—— *Hameri* (*Ascanius*). 40–50 fathoms; scarce.

—— *balanoides* (Linn.). Common.

Verruca Strömia (Müller). Common on shells and stones in deep water.

Scalpellum vulgare, Leach. Down to 60 fathoms, St. Magnus Bay, Whalsey Skerries Haaf; off Balta &c.

Alcippe lampas, A. Hancock, Ann. & Mag. Nat. Hist. 2nd ser. vol. iv. (1849) p. 305, pls. viii. ix. In the shell of *Fusus antiquus*, dredged in 40–50 fathoms, 5–8 miles east of Balta.

Order PYCNOGONOIDEA.

Pycnogonum littorale, Ström. Very common under stones, tide-marks; and also in deep water to 50 fathoms.

Phoxichilidium femoratum (Rathke) = *Phoxichilidium coccineum*, Johnston. Common, tide-marks.

Nymphon giganteum, Johnston. Occasional, deep water.

—— *Strömii*, Kröyer, Naturhist. Tidssk. Andet Række (1844), vol. i. p. 111; Gaimard, Voyages en Scandinavie &c. pl. xxxv. fig. 3. A single specimen, the only known British example, dredged in 1861 in 80 fathoms, 40 miles east of Whalsey Skerries.

—— *hirtum*, O. Fab. One mile north of Whalsey Skerries Lighthouse, in 40–50 fathoms.

—— *mixtum*, Kröyer. St. Magnus Bay, 1867.

Class ARACHNIDA.

Order ACARINA.

Halacarus ctenopus, Gosse, Ann. Nat. Hist. 2nd ser. vol. xvi. (1855) p. 28,

pl. iii. figs. 6–10. Common among seaweeds in littoral and laminarian zones.

Pachygnathus notops, Gosse, Ann. Nat. Hist. 2nd ser. vol. xvi. (1855) p. 304, pl. viii. figs. 1–4. Abundant on weeds in rock-pools, Balta Sound, 1867.

Class TUNICATA.

My entire collection of Tunicata having been placed in Mr. Alder's hands for use in the preparation of the work which, in conjunction with Mr. A. Hancock, he had undertaken for the Ray Society, and which will be shortly published, the nomenclature of the following list may be relied upon. Species of *Botryllus*, *Botrylloides*, and allied genera are numerous in Shetland, but it being impossible to preserve them satisfactorily, and not having works with me, I was unable to identify more than two or three species with any degree of certainty, and have thought it better therefore entirely to omit these genera in the present Report, and leave them for some future investigator to work out.

Pelonaia corrugata, Forbes & Goodsir. A single small specimen off the Island of Balta.

Ascidia intestinalis, Linn. At low water, West Voe, Whalsey Skerries, and Lerwick.

—— *venosa*, Müller. Middle Haaf, off Out Skerries, 40–50 fathoms; also Haroldswick Bay.

—— *mentula*, Müller. Middle Haaf.

—— *rudis*, Alder, Ann. Nat. Hist. 1863, vol. xi. p. 155. The type specimens were taken at low-water mark near the Whalsey Lighthouse, Out Skerries, 1861.

—— *obliqua*, Alder, Ann. Nat. Hist. 1863, vol. xi. p. 154. The type specimens were dredged in 40–50 fathoms on the Outer Haaf, due east of Whalsey Lighthouse, in 1861; also several fine examples, in about the same depth of water, between the islands of Whalsey and Balta, 1867.

—— *sordida*, Alder & Hancock. 50–80 fathoms, and common. In most extraordinary profusion, on sandy ground, 7–10 miles east of the Isle of Balta, in company with *Tubularia gracilis*, *Eudendrum*, *Zoanthus papillosus*, which all occur in greater quantity in that locality than elsewhere in Shetland. In one spot the dredge came up again and again literally filled with *A. sordida*.

—— *virginea*, Müller. "Zetland, R. M'Andrew & E. Forbes" (Forbes & Hanley). It is probable that the last species is meant.

—— *parallelogramma*, Müller. Apparently rare, one specimen only, 10 miles east of Balta.

—— *depressa*, Alder & Hancock. Low water, Island of Housay, in company with the following species.

—— *scabra*, Müller. Island of Housay (Out Skerries), in the West Voe, spring tides, common.

—— *elliptica*, Alder & Hancock. Low water, Lerwick, 1861.

—— *plebeia*, Alder, Ann. Nat. Hist. 1863, vol. xi. p. 155. Forty miles east of Whalsey Lighthouse, 1861, the type specimens.

Molgula arenosa, Alder & Hancock; Alder, Ann. Nat. Hist. 1863, vol. xi. p. 160; *Molgula tubulosa*, Forbes & Hanley, vol. i. p. 36 (but not *M. tubulosa*, Müller). Common on the Haddock-grounds between Whalsey and Feltar; east of Balta; St. Magnus Bay, &c.

Molgula citrina, Alder & Hancock. Low water, Lerwick, 1861.
Cynthia coriacea, Alder & Hancock. Dourie Voe, 1863.
—— *grossularia*, Van Beneden. Common between tide-marks.
—— *echinata*, Linn.; *Ascidia echinata*, Forbes & Hanley, vol. i. p. 35, pl. C. fig. 4. 5–40 fathoms, Middle Haaf and Bressay Sound, 1863. Parasitic on *Ascidia sordida*, 5–8 miles east of Balta, 40–50 fathoms, 1867.
Clavelina lepadiformis, Müller. One mile north of Whalsey Lighthouse, 1861.
Polyclinum aurantium, M.-Edwards. 3–5 fathoms, Out Skerries Harbour.
—— *succineum*, Alder, Ann. Nat. Hist. 1863, vol. xi. p. 169. The type specimen was dredged in 1861, in 50 fathoms, on the Haddock-ground, 6 miles north of Whalsey Lighthouse.
Amarœcium albicans, M.-Edwards, Observ. sur les Ascidies Composées, p. 287, pl. i. fig. 3 *b*. Low water, Lerwick.
—— ——? An undetermined species, tide-marks, Balta Sound, 1863.
Botryllus and *Botrylloides*. About ten species observed, but not determined satisfactorily.
Leptoclinum durum, M.-Edwards = *Leptoclinum aureum* (misprint), Forbes & Hanley, vol. i. p. 17. Tide-marks, West Voe, Out Skerries, 1861.
—— *punctatum*, Forbes. With the last.
Didemnum gelatinosum, M.-Edwards, Obs. Ascid. Compos. p. 295, pl. vii. fig. 5. Low water, spring tides, West Voe, Out Skerries; and in Out Skerries Harbour, on roots of Laminariæ.
Parascidia Flemingii, Alder, Ann. Nat. Hist. 1863, vol. xi. p. 172. *Sidnyum turbinatum*, Fleming. Low water, Lerwick. In Mr. Alder's opinion this is not the *Sidnyum turbinatum* of Savigny (Mém. Anim. sans Vertèbres, vol. ii. p. 238), nor the *Sidnyum turbinatum* of Forbes and Hanley, which he also considers distinct from Savigny's species, and proposes to name *Parascidia Forbesii*.
Salpa runcinata, Chamisso. Both sexual and asexual forms in vast numbers, in company with *Diphyes* and *Physophora*, 30–35 miles, N.N.W. of Burrafirth Lighthouse, July 17 and 18, 1867.
Appendicularia flagellum, Huxley. Some *Appendiculariæ* were taken by me in the towing-net in Balta Sound in 1863, which I believe belonged to this species; but the bottle in which they were preserved was unfortunately lost (I conclude left behind in Shetland), and thus also the accurate determination of the species.

Class POLYZOA.

For this class I have adopted, as far as it goes, the general arrangement of Mr. Busk, in 'A Monograph of the Fossil Polyzoa of the Crag, 1859.' This work having been published subsequently to the 'Catalogue of Marine Polyzoa in the collection of the British Museum, 1852,' gives us the author's maturer views. With respect to the species, if no reference to other works is given, they will be found described in the 'Catalogue;' but, as will be seen by the following Report, our knowledge of the animals of this class has been very materially extended since 1852. Herr F. A. Smitt has just published a valuable series of papers on the Polyzoa of the Scandinavian seas, entitled "Kritisk förteckning öfver Skandinaviens Hafs-Bryozoer" (Öfvers. af K. Vet.-Akad. Förhandl. 1865–67), but I am not prepared to acquiesce in his views as to the amount of variation to be observed in species of the class.

Suborder CHEILOSTOMATA.

Scrupocellaria scruposa (Linn.). Attached to old shells of Mollusca and *Ditrupa*, and on *Celleporæ*, from 40–80 fathoms.

—— *inermis*, Norman, Report Brit. Assoc. 1866 (1867), p. 203; Quart. Journ. Mic. Sci. vol. viii. N. S. p. 215, pl. v. figs. 1–3. Rare, 5–8 miles off Balta, in 40–50 fathoms.

Cellularia Peachii, Busk. Haddock-grounds and Outer Haaf, frequent.

Menipea ternata (Ellis & Sol.). On *Tubularia indivisa*, dredged in 70 fathoms.

—— *Jeffreysii*, Norman, Quart. Journ. Mic. Sci. N. S. vol. viii. (1868), p. 213, pl. v. figs. 3–5. Only small fragments of this species, found among dredged sand, have as yet been observed, 1864.

Canda reptans (Pallas). "On coral, from 100 fathoms, Outer Haaf, Unst" (Peach, 1864).

Salicornaria farciminoides (Ellis & Sol.). 40–70 fathoms.

—— *sinuosa*, Hassall, Busk, Mon. Crag Polyzoa, p. 23, pl. xxi. fig. 5; Alder, Cat. Zooph. Northumberland and Durham, p. 61. In similar localities to the last.

—— *Johnsoni*, Busk=*Nellia Johnsoni*, Busk, Quart. Journ. Mic. Sci. N. S. vol. vi. (1858) p. 125, pl. xix. fig. 2, =*Cellaria Johnsoni*, id. ibid. vol. vii. (1859) p. 65, pl. xxiii. figs. 4–5, =*Salicornaria Johnsoni*, id. ibid. vol. viii. (1860) p. 280. Middle Haaf, a much more delicate species than the last two.

Caberea Ellisii (Fleming). *Caberea Hookeri*, Busk, Cat. Marine Polyz. p. 39, pl. xxxvii. fig. 2, =*Caberea Ellisii*, Norman, Quart. Journ. Mic. Science, N. S. vol. viii. (1868) p. 217. Abundant, 40–70 fathoms.

Bicellaria ciliata (Linn.). "Very rare, 45 fathoms, Haddock-ground, Out Skerries" (Peach, 1864).

—— *Alderi*, Busk, Quart. Journ. Mic. Science, N. S. vol. viii. (1860) p. 213, pl. xxviii. figs. 1–3; Smitt, Öfversigt af K. Vet.-Akad. Förh. 1867, p. 289, pl. xviii. figs. 4–8; Norman, Quart. Journ. Mic. Sci. vol. viii. (1868) p. 218, =*Bicellaria unispinosa*, M. Sars. Dredged in 40–100 fathoms, off Unst and Out Skerries. The locality in which I met with it most frequently was 5–10 miles east of Balta, in 40–70 fathoms, in company with amazing numbers of *Ascidia sordida*, with which the dredge came up time after time completely filled. It generally lives attached to Hydrozoa (*Tubularia*, &c.).

Bugula avicularia (Pallas). Not common.

—— *purpurotincta*, Norman, Quart. Journ. Mic. Sci. N. S. vol. viii. (1868) p. 219, =*B. fastigiata*, Alder, Cat. Zoophytes Northumberland and Durham, p. 59. Scarce, 5–7 miles east of Balta, 40–50 fathoms.

—— *Murrayana* (Bean).

—— *flabellata* (J. V. Thompson). "15–50 fathoms, Dourie Voe and Haddock-ground, Out Skerries and Unst" (Peach, 1864). I do not remember myself having seen the species.

Flustra foliacea, Linn.

—— *truncata*, Linn.

—— *Barleei*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 123, pl. xxv. fig. 4, =*Flustra membranaceo-truncata*, Smitt, Öfvers. af K. Vet.-Akad. Förh. 1867, p. 358, pl. xx. figs. 1–5.

Very local, between Whalsey and Balta, and off Unst, in about 50 fathoms.

Carbasea papyrea (Pallas). From fishing-boats, Middle Haaf.
Gemellaria loriculata (Linn.). Occasionally met with.
Ætea sica (Couch). *Hippothoa sica*, Couch, Corn. Fauna, iii. p. 102, pl. xix. fig. 8, =*Ætea recta*, Hincks, Cat. Zoophytes Devon and Cornwall, p. 35, pl. vii. fig. 3.
40–80 fathoms, on shells and stones, frequent.
Hippothoa catenularia (Jameson). Common on stones in 40–170 fathoms.
—— *divaricata*, Lamx. 40–90 fathoms on shells, more rarely on stones.
—— *expansa*, Norman, Quart. Journ. Mic. Sci. vol. viii. (1868) p. 216, pl. vi. figs. 1, 2. The type, and only known specimen, dredged in 100 fathoms off Unst in 1864.
Membranipora membranacea (Linn.).
—— *pilosa* (Linn.).
—— *coriacea* (Esper.). On underside of stones between tide-marks.
—— *lineata* (Linn.), Alder, Cat. Zooph. Northumberland and Durham, p. 53, pl. viii. fig. 1. On roots of Fuci and Laminariæ.
—— *spinifera* (Johnston), Alder, Cat. Zooph. Northumberland and Durham, p. 53, pl. viii. fig. 2. On stones, tide-marks.
—— *Flemingii*, Busk. 15–100 fathoms.
—— *craticula*, Alder, Catal. Zooph. Northumberland and Durham, p. 54, pl. viii. fig. 3. On a stone from shallow water, Hillswick, and roots of Laminariæ, Bressay Sound.
—— *Dumerillii* (Audouin)=*Flustra Dumerillii*, Audouin, Savigny, Hist. l'Egypt, pl. x. fig. 12, =*Membranipora Pouilletii*, Alder, Cat. Zooph. Northumberland and Durham, p. 56, pl. viii. fig. 5; Quart. Journ. Mic. Sci. N. S. vol. v. (1857) p. 248 (but not *Flustra Pouilletii*, Audouin, Savigny Hist. l'Egypt, pl. ix. fig. 12). Occasional on *Cellepora cervicornis* and shells. A curious mistake has been made by Alder and Busk respecting this species, which is clearly that represented by Savigny's pl. x. fig. 12, viz. *Flustra Dumerillii*, instead of which the name of pl. ix. fig. 12 has been quoted *Flustra Pouilletii*, which bears not the slightest resemblance to the present form, being a *Lepralia* allied to *L. innominata*.
—— *unicornis* (Fleming), Alder, Cat. Zooph. Northumberland and Durham, p. 56, pl. viii. fig. 6. "Tide-marks, Balta Sound" (Peach, 1864).
—— *cornigera*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. 1860, p. 124, pl. xxv. fig. 2. A very interesting and very rare species; 100 fathoms, Outer Haaf.
—— *imbellis*, Hincks, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 275, pl. xxx. fig. 1. Rare, 40–50 fathoms, 5–7 miles east of Balta.
—— *rhynchota*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 125, pl. xxv. fig. 1 (called *M. minax* in text); Crag Polyzoa, p. 33, pl. iii. fig. 7. In 40–170 fathoms, common; the most abundant species in deep water, it encircles the dead shells of *Dentalium* and *Ditrupa* with its polyzoary.
—— *Rosselii* (Audouin). On stones, Outer Haaf, 80–140 fathoms.
—— *sacculata*, Norman, Ann. Nat. Hist. 3rd ser. vol. xiii. (1864) p. 88, pl. xi. fig. 3. Common, 40–170 fathoms, on stones and shells.
—— *vulnerata*, Busk, Quart. Journ. Mic. Science, N. S. vol. viii. (1860) p. 124, pl. xxv. fig. 3. In 80–110 fathoms. This very distinct little species has a very peculiar habit; it is never found on any but the smallest stones. I do not remember to have *ever* seen it on a pebble larger than the little finger-nail; more generally it selects those that are not more than a fourth of that size.

Alysidota Alderi, Busk, Quart. Journ. Mic. Science, N. S. vol. iv. (1856) p. 311, pl. ix. figs. 6, 7, =*Lepralia Barleei*, id. ibid. vol. viii. (1860) p. 143, pl. xxvi. figs. 1, 2. Common, 50–170 fathoms. In its chain-like form it is the *Alysidota Alderi*, and when living in groups Busk's *Lepralia Barleei*. The two varieties are occasionally found passing into each other. The type specimens of both are in my collection.

Lepralia Brongniartii (Aud.). 40–100 fathoms, frequent.

—— *reticulata*, Macg. Rare, 80 fathoms.

—— *crystallina*, Norman, Report Brit. Assoc. 1866 (1867), p. 204. On shells and stones, 80–140 fathoms.

—— *auriculata*, Hassall. To 100 fathoms.

—— *concinna*, Busk. 40–170 fathoms.

—— *bella*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 144, pl. xxvii. fig. 2. A fine species, abundant on large stones on the Outer Haaf, to 170 fathoms.

—— *sinuosa*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 125, pl. xxiv. figs. 2 & 3. On stone and shell, Outer Haaf.

—— *verrucosa* (Esper.). Tide-marks and shallow water.

—— *cruenta*, Norman, Ann. Nat. Hist. 3rd ser. vol. xiii. 1864, p. 88. Rare, 80–100 fathoms.

—— *spinifera*, Johnst., Busk, Cat. Marine Polyzoa, p. 69, pl. lxxvi. figs. 2, 3 (but not the other figures referred to at p. 69). On stones and roots of Laminariæ, tide-marks and shallow water, Balta Sound, Hillswick, and Lerwick.

—— *unicornis*, Johnst., =*L. ansata*, Busk, Crag Polyzoa, p. 45, pl. vii. fig. 2. Mr. Busk appears to me to have transposed the names of this and the following species. What I consider to be the true *unicornis* is the species evidently referred to by that name in the 'Catalogues' of Alder and Hincks. It is common between tide-marks.

—— *ansata*, Johnston, =*L. unicornis*, Busk, Crag Polyzoa, p. 45, pl. v. fig. 4. This species is distinguished from the last by its short and very broad cells, and by the much smaller size of its ovicells. It is a deep-water form, and is extremely abundant in the Shetland seas, in 40–170 fathoms. Whether this is really a distinct species from *L. unicornis* is perhaps doubtful.

—— *trispinosa*, Johnston. Found down to 170 fathoms. A pretty variety coating a *Ditrupa*, has the punctures round the margin more conspicuous than usual, an avicularium on the front of the cell in the centre, with its mandible pointing directly downwards, and the ovicell cleft with wedge-shaped openings, which radiate from the sides towards the centre.

—— *coccinea*, Abildgaard. Abundant between tide-marks and in shallow water.

—— *Ballii*, Johnston. On shells, 30–50 fathoms.

—— *linearis*, Hassall. Common down to 170 fathoms.

Var. 1. *hastata*, Hincks, Cat. Zoophytes Devon and Cornwall, pp. 46 and 63, pl. xii. fig. 4. On *Cellepora cervicornis*, off the Island of Balta.

Var. 2. *crucifera*. With the usual avicularia on each side of the cells, and with a central, suboral process rising from the cell in the form of a very long, gradually tapering, rugose, perpendicular spine, which is more than equal the length of the entire cell, and in its most perfect state gives off a branch at nearly right angles at rather more than half its height, so that the whole process is in the form of a cross or trident.

On a shell dredged in 40–50 fathoms off Unst. A very remarkable form.

Lepralia ciliata (Linn.). Tide-marks to 90 fathoms.

—— *Hyndmanni*, Johnst. 80–110 fathoms.

—— *Woodiana*, Busk, Crag Polyzoa, p. 42, pl. vii. figs. 1 & 3; Hincks, Cat. Zoophytes Devon and Cornwall, p. 42. Very abundant in deep water, 80–170 fathoms.

—— *discoidea*, Busk, Quart. Journ. Mic. Sci. N. S. vol. vii. (1859) p. 66, pl. xxii. figs. 7, 8; id. ibid. vol. viii. (1860) p. 144, pl. xxvii. figs. 4, 5; Hincks, ibid. vol. viii. p. 276, pl. xxx. fig. 4. "Shetland, Barlee" (Busk).

—— *nitida* (Fabr.). Tide-marks and shallow water.

—— *annulata* (Fabr.). Roots of Laminariæ and stones, shallow water.

—— *Peachii*, Johnst. To 170 fathoms.

—— *ventricosa*, Hassall. 15–170 fathoms.

—— *laqueata*, Norman, Ann. Nat. Hist. 3rd ser. vol. xiii. (1864) p. 85, pl. x. fig. 5. 80–170 fathoms, frequent.

—— *abyssicola*, n. sp. Polyzoary irregular, in patches of considerable size. Cells irregularly arranged, pointing this way and that, not in quincunx, widest in the middle, tapering thence above and below, moderately convex; surface dull, minutely granular, no raised lines or rows of perforations separating the cells: mouth small, terminal; lower lip advanced, encroaching on the mouth, convex, pouting, a denticle within the mouth, wide, little raised, and so deeply seated that it cannot be seen unless carefully looked for; upper lip free, bearing two spines (which, however, are very rarely present). Ovicell globose, tumid, wider in the centre than the top of the cell, with a little transverse rib (caused by the upper lip) just over the mouth; surface minutely granular as the cells; these minute granulations appear to be centrally punctate. The form of the ovicells and mouth in the fertile cells remind one forcibly of a helmet with the vizor raised. An inhabitant of the deepest water, having been only found in 140–170 fathoms to the N.N.W. of Unst.

This species comes very near to *L. microstoma*, but is, I think distinct. The cells are very much larger, the mouth less tubular and raised, the ovicells less thrown back off the mouth; and there is a deeply seated denticle in the mouth, which does not seem to be the case in *L. microstoma*.

—— *polita*, Norman, Ann. Nat. Hist. 3rd ser. vol. xiii. (1864) p. 87, pl. xi. fig. 1. 70–170 fathoms.

—— *microstoma*, Norman, Ann. Nat. Hist. 3rd ser. vol. xiii. (1864) p. 87, pl. xi. fig. 2. 20–25 miles N. and N. by W. of Unst. 80–140 fathoms.

—— *innominata*, Couch. Scarce, down to 170 fathoms.

—— *punctata*, Hassall. Tide-marks, common.

—— *ringens*, Busk, Quart. Journ. Mic. Sci. N. S. vol. iv. (1856) p. 308, pl. ix. figs. 3–5. 80–170 fathoms.

—— *bispinosa*, Johnst. On stones and shells, 50–170 fathoms. Differing from Guernsey specimens in the much larger size of the cells.

—— *umbonata*, Busk, Quart. Journ. Mic. Sc. N. S. vol. viii. (1860) p. 143, pl. xxvii. fig. 1. "On stone, Shetland, Barlee" (Busk).

—— *collaris*, Norman, Report Brit. Assoc. 1866 (1867), p. 204. Scarce, 80–100 fathoms.

—— *Pallasiana* (Möll.) = *L. cantharifformis*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 143, pl. xxvi. figs. 3, 4. Common between tide-

marks. *L. canthariformis*, Busk, seems to be nothing else than this species with the cells a little more erect than usual.

Lepralia pertusa (Esper). On shells, especially Ditrupæ, and stones, 40–100 fathoms.

—— *labrosa*, Busk. Scarce, 40 fathoms.

—— *simplex*, Johnst. "45 fathoms, Haddock-ground, Unst, Peach, 1864" (*fide* Alder in litt.).

—— *Malusii* (Audouin). Tide-marks to 50 fathoms.

—— *minuta*, n. sp. Cells minute, arranged in remarkably regular lines, diverging from a centre; the parts about the mouth raised in a pustular manner; mouth horseshoe-shaped, the central portion of the lower lip encroaching on the aperture, sometimes in a rounded, at others in a more denticulate and bifid form; surface granulated, margins between cells areolated; ovicells subimmersed, granular, imperforate. In very small roundish patches on stone. Shetland, very rare, and Guernsey (A. M. N.); Wick (Mr. Peach).

—— *tubulosa*, n. sp. Cells shortly ovate, hyaline, smooth, glistening, punctate; mouth produced into a very long tube, which stands upright from the polyzoary, aperture round, peristome thin and simple; on the cell just below the origin of the tube a conspicuous pore. A remarkable form, wholly unlike any other species; found on a stone dredged in a few fathoms water at Hillswick.

—— *monodon*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 213, pl. xxix. figs. 3, 4. Common, in 80–170 fathoms.

—— *granifera*, Johnst. Underside of stones, tide-marks.

Celleporella hyalina (Linn.), Gray, List of British Radiated Animals in Brit. Mus. pp. 128 & 149. On rocks and weeds.

—— *lepralioides*, Norman, Quart. Journ. Mic. Sci. vol. viii. (1868) p. 222, pl. vii. figs. 4, 5. On stones, 80–140 fathoms.

—— *pygmæa*, n. sp. Cells cylindrical, semierect, immersed through a considerable part of their height; peristome raised, simple, unattached all round, more elevated at the sides of the cylindrical aperture; surface nearly smooth and imperforate. Ovicells galeate, depressed in front, imperforate. No avicularia. A minute species, presenting very little character, but manifestly distinct from its allies. Occurs in little round patches, which are seldom more than a tenth of an inch in diameter; the largest patch seen not a fifth of an inch; on stones from very deep water, in 80–170 fathoms, where it is not uncommon.

Cellepora pumicosa, Linn.

—— *avicularia*, Hincks, Cat. Zooph. Devon and Cornwall, p. 48, pl. xii. fig. 6. In "nodulous rolls" on Tubularia, Sertulariæ, &c.

—— *Hassallii* (Johnst.). Rocks, and roots of Laminariæ.

—— *ramulosa*, Linn. 40–170 fathoms.

—— *dichotoma*, Hincks, Cat. Zooph. Devon and Cornwall, p. 49, pl. xii. figs. 7, 8; Alder, Quart. Journ. Mic. Sci. vol. iv. (1864) p. 96, pl. ii. figs. 2–4. Living attached to Sertularian Hydrozoa, in 40–70 fathoms.

—— *attenuata*, Alder, Quart. Journ. Mic. Sci. vol. iv. p. 97 (1864), pl. ii. figs. 5–8. Local, 80–110 fathoms, 20–25 miles N.N.E. of Unst.

—— *cervicornis* (Ellis and Sol.). 40–170 fathoms. The Shetland forms are much less massive than that of the Devon and Cornish coast. Sometimes they are a great deal branched, the branches interlacing and crossing each other in all directions, and more or less flattened. A rarer form has but few branches, and these very long, simple (*i. e.* not dicho-

tomously dividing), and round. Placed side by side with Cornish specimens this looks very different, but the microscopic characters appear to be identical.

Palmicellaria elegans, Alder, Quart. Journ. Mic. Sci. vol. iv. (1864) p. 100, pl. ii. figs. 1–4. A beautiful little species, 80–110 fathoms, eighteen to twenty-five miles N. and N.N.W. of Burrafirth Lighthouse.

Tessaradoma gracile (Sars) = *Pustulipora gracilis*, Sars, Reise Lof. Finm. 1850, p. 26, = *Quadricellaria gracilis*, Sars, Beskr. Norske Polyz. p. 15; Alder, Quart. Journ. Mic. Sci. vol. iv. (1864) p. 101, pl. ii. figs. 9–12, = *Onchopora borealis*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 213, pl. xxviii. figs. 6, 7, = *Anarthropora borealis*, Smitt, Öfvers. af K. Vet.-Akad. Förh. 1867, Bihang, p. 8, pl. xxiv. figs. 25–29. Rather local, but not rare on the Outer Haaf. It is necessary that the generic name *Quadricellaria*, which is preoccupied, should be changed. Smitt has instituted a genus *Anarthropora* to receive *Lepralia monodon* and the present species! Such a union, in my opinion, cannot stand. Leaving, therefore, *L. monodon* as the type of Smitt's genus, I propose the name *Tessaradoma*, the characters of which will be those given by Alder, *l. c.* I have not adopted the genus *Anarthropora* for *L. monodon* in this Report, because an entire rearrangement of the Membraniporidæ is required, and until that entire rearrangement is carried out (and this I hope shortly to do), I have thought it better not to partially dismember the genus *Lepralia*.

Hemeschara struma, Norman, Quart. Journ. Mic. Sci. vol. viii. (1868) p. 221, pl. vii. figs. 6–8. In 100 fathoms, about twenty-five miles north of Unst, attaching itself to stones and the branches of *C. cervicornis*, and running out into free expansions.

Eschara Landsborovii (Johnst.), Alder, Quart. Journ. Mic. Sci. vol. iv. (1864) p. 105, pl. iv. figs. 1–3. Very rare; the Lepralian state on a stone from 170 fathoms.

—— *lævis* (Fleming), Alder, Quart. Journ. Mic. Sci. vol. iv. (1864) p. 102, pl. iii. figs. 8–11. Scarce, in about 100–170 fathoms, 20–25 miles N. and N.N.E. of Unst.

—— *Skenei* (Ellis and Sol.) = *Cellepora Skenei*, Busk, Marine Polyzoa, p. 88, pl. cxxii. 40–70 fathoms, 5–10 miles east of Balta; also Out Skerries Haaf.

—— *lorea*, Alder, Quart. Journ. Mic. Sci. vol. iv. (1864) p. 104, pl. iii. figs. 5–7. 80–100 fathoms, 20–25 miles north of Burrafirth Lighthouse. Certainly distinct from the last, with which it is united by Smitt.

Retipora Beaniana, King. Occasionally on the Unst Haaf, down to 170 fathoms; abundant on the Out Skerries Haaf, but not so large as on the Northumberland coast.

Suborder Cyclostomata.

Crisia eburnea (Linn.). On Hydrozoa on haddock-grounds.

Var. *producta*, Smitt, Öfvers. af K. Vet.-Akad. Förh. 1865, p. 116, pl. xvi. figs. 4–6. On stones, 100–170 fathoms.

—— *denticulata* (Lamk.). On Zoophytes, Haddock-ground.

—— *aculeata*, Hassall. "Tide-marks to Haddock-ground" (Peach, 1864); "Shetland, Barlee" (*fide* Alder in litt.).

Crisidia cornuta (Linn.). On rocks between tide-marks.

Hornera borealis, Busk, Alder, Quart. Journ. Mic. Sci. vol. iv. (1864) p. 108, pl. iv. figs. 1–6. 80–170 fathoms, Outer Haaf.

Hornera violacea, Sars, Geol. og Zool. Jagtt. Reise Trondhj. St. Somm. 1862 (1863), p. 30; Smitt, Öfvers. af K. Vet.-Akad. Förh. 1866, p. 404, pl. vi. figs. 2–9.

In general form like the last, but the back, instead of being striated, is granulated; the branches at their extremities with a rib-like elevation down the centre, the front having the cells more crowded and much more produced than in *borealis*; ovicells elongated, in the axils of the branches, generally (in my specimens) with one part on the front, but coming round the branch, the greater part lies on the back of the polyzoary, with a very slight longitudinal riblet, otherwise smooth, and closely punctate. Colour white with a violet tinge. In about 50 fathoms, about seven miles E.S.E. from Balta, rare. Now first added to our fauna.

Idmonea Atlantica, Forbes. Outer Haaf, 70–140 fathoms.

—— *serpens* (Linn.) = *Tubulipora serpens*, Johnst. On Sertulariæ, &c., common.

Pustulipora deflexa (Couch). "Shetland, Peach, 1864" (*fide* Alder in litt.).

—— *orchadensis*, Busk, Quart. Journ. Mic. Sci. N. S. vol. viii. (1860) p. 214, pl. xxix. figs. 1, 2. "Shetland, Barlee" (Busk). The collection of the late Mr. Barlee, which was bequeathed by him to myself, does not contain any Polyzoon which I can identify as the type of this species described by Busk.

Tubulipora lobulata, Hassall. On stones, 30–70 fathoms.

—— *flabellaris*, Johnst. "Shetland, Peach, 1864" (*fide* Alder in litt.).

Alecto granulata, M.-Edwards. Dourie Voe and Haddock-grounds; also Outer Haaf to 170 fathoms.

—— *major*, Johnst. Common to 170 fathoms.

—— *dilatans*, Johnst. 80–140 fathoms. Compared with the types in B. M.

—— *compacta*, Norman, Report Brit. Assoc. 1866 (1867), p. 204. On stones, Outer Haaf, Unst, and Out Skerries, in 80–170 fathoms. It is, I believe, the *Alecto dilatans*, var., Johnston, p. 282, pl. xlix. figs. 7, 8.

—— *diastoporides*, n. sp. Polyzoary lobulate, the branches diverging from a common centre, and rapidly widening into fan-formed terminations, appressed very flatly to stones or shells, closely punctate, but a transparent looking line (the appearance caused by absence of punctures) marking the course of each side of each concealed tube in a similar way to the transparent lines in *D. obelia*; cells scattered irregularly, many being present on the expanded terminations; mouth but little raised above the crust, opening vertically.

This is the largest *Alecto* in our seas, and a very marked species. It is found on shell and stone, in 70–110 fathoms.

Mr. Peach has also sent me the species from Wick, including a specimen nestling in a sheltered spot of the inside of a valve of *Tapes virginea*, which has the cell-tubes erect and long; in all other specimens which I have seen they are very short.

Diastopora obelia (Fleming). Down to 170 fathoms, common.

Patinella patina (Lamk.). Common to 170 fathoms.

Var. *prolifera*, Busk, Crag Polyzoa, p. 114, pl. xix. fig. 1, and pl. xx. fig. 3. Frequent on *Cellepora cervicornis* and *Eschara lævis*.

Discoporella hispida (Fleming). Common to 170 fathoms.

Defrancia truncata (Jameson). Not uncommon on the Outer Haaf, in 70–170 fathoms.

Suborder Ctenostomata.

Alcyonidium gelatinosum (Pallas). 40–50 fathoms, 5–8 miles east of Balta, sandy bottom, with immense quantities of Hydrozoa and Tunicata; also 40 fathoms, six miles north of Whalsey Lighthouse.

—— *hirsutum* (Fleming). On *Fuci*, tide-marks, Balta Sound, and Out Skerries, abundant.

—— ? A third species was found by me in 1861 between tide-marks, West Voe, Out Skerries. Mr. Alder, who examined it for me, gave me the MS. name for it, "*Alcyonidium radiatum*."

Arachnidia hippothooides, Hincks, Cat. Zoophytes Devon and Cornwall, p. 57, pl. xvi. fig. 2. Creeping over the test of *Ascidia sordida*; dredged 5–8 miles off Balta.

Flustrella hispida (Fabr.) = *Flustra hispida*, Johnst. Brit. Zooph. p. 263, pl. lxvi. fig. 5, = *Flustrella hispida*, Gray, Brit. Radiated Anim. Brit. Mus. p. 108; Redfern, Quart. Journ. Mic. Sci. N. S. vol. vi. 1858, p. 96, pl. iv., = *Alcyonidium hispidum*, Smitt, Öfvers. af K. Vet.-Akad. Förh. 1866, p. 499, pl. xii. figs. 22–27. On *Fuci*, *Chondrus*, and other seaweeds; common.

Vesicularia spinosa (Linn.). "Shetland, 1858, Barlee" (*fide* Alder in litt.).

Buskia nitens, Alder, Cat. Zooph. Northumb. and Durham, p. 66, pl. v. figs. 1, 2; Quart. Journ. Mic. Sci. N. S. vol. v. 1857, p. 24, pl. xiii. figs. 1, 2. "On *Halecium labrosum*, procured by Mr. Barlee" (Alder in litt.).

Valkeria cuscuta (Linn.). Procured in 1861.

Bowerbankia imbricata (Adams). Tide-marks, common.

Avenella fusca, Dalyell, Rare and Rem. Anim. Scot. vol. ii. p. 65; vol. i. pl. xii. fig. 11; Alder, Cat. Zooph. Northumb. and Durham, p. 69, = *Farrella fusca*, Busk, Quart. Journ. Mic. Sci. vol. vi. fig. 3, = *Farrella dilatata*, Hincks, Quart. Journ. Mic. Sci. vol. viii. p. 279, pl. xxx. fig. 7; Cat. Zooph. Devon and Cornwall, p. 30. Parasitic on the tests of Ascidians from deep water.

Suborder Pedicellinea.

Pedicellina Belgica, Van Ben. Recognized by Mr. Alder on some Shetland Hydrozoa sent to him in 1861.

—— *gracilis*, Sars. On *Sertularia*, 1863; rare.

—— *echinata*, Sars. "In Dourie Voe, 15 fathoms, 1864" (*fide* Peach).

Suborder Lophopea.

I have pleasure in announcing the discovery in the Shetland seas of a species of this interesting tribe, which up to the present time has been supposed to embrace only freshwater forms. *Rhabdopleura* was dredged by me in the Outer Haaf, and being unable to recognize it, I sent it to Professor Allman for his opinion, and the extract from a letter received from him, given below, will show the result of his examination.

Rhabdopleura Normani, Allman, nov. gen. et sp. "Now with regard to the new genus. Expecting nothing but hydroids in your bottles, and being satisfied on a rapid glance that the contents of one bottle were something very different from any known hydroid, I at once set the specimen down in my mind as that of a new genus of Campanularians. I now find that it is no hydroid, but a very curious and new genus of Polyzoa. So interesting a form is it that I thought it worth while spending some

time over its thorough investigation . . .; and so by the help of acetic and chromic acids and liquor potassæ, I have succeeded in very fairly unravelling the structure of your Polyzoon. It is a true Hippocrepian form, as entirely and typically so as *Plumatella*—a fact which gave facility to my examination, as I had already made the Hippocrepian Polyzoa a special subject of study. One of its most remarkable features is a rigid rod which runs through the cœnœcium, and to which the polypides are attached, each by a funiculus. This rod was the only thing at first visible besides the polypides and their tubes of insertion; but I afterwards found that the whole of the rod and its attached polypides were contained in a most delicate and colourless cœnœcium, into which the free tubes of insertion were continued. The remarkable internal rod will well suggest a generic name, and I have accordingly thought of *Rhabdopleura* as sufficiently significant and distinctive."—Allman in litt. Outer Haaf off Unst, in 93 fathoms.

Class ECHINODERMATA.

The *Crinoidea*, *Ophiuroidea*, and *Asteroidea* in the following notes are arranged in accordance with my paper "On the Genera and Species of British Echinodermata" in the 'Annals of Nat. Hist.' for February 1865. With respect to the *Echinoidea* and *Holothuroidea*, I give references where the nomenclature of Forbes's 'British Starfishes' is not sufficient to indicate the species.

Order CRINOIDEA.

Antedon rosaceus (Linck). In the Voes and thence down to 40 fathoms, not uncommon, and attaining an unusually large size. Very abundant on Laminariæ, in Bressay Sound, off Lerwick.

—— *Sarsii* (Düben & Koren). 80–100 fathoms, 40 miles east of Whalsey Lighthouse; very local, but gregarious where found.

Order OPHIUROIDEA.

Astrophyton Linckii, Müll. & Trosch = *A. scutatum*, Forbes. Off the west coast, in very deep water (*vide* Forbes, British Starfishes). It has not been procured during the recent dredgings off the east and north coasts, nor do the fishermen on those sides of the island appear to be acquainted with the species.

Ophiothrix fragilis (Müller) = *Ophiocoma rosula* and *minuta*, Forbes. Having a very great range in depth, living between tide-marks and thence down to 170 fathoms, the deepest water dredged.

Amphiura filiformis (Müller). 3 fathoms, Balta Sound; Out Skerries Haddock-ground, and in St. Magnus Bay, 30–60 fathoms.

—— *Chiajii*, Forbes. Off Balta; on the Haddock-ground near the Out Skerries, and in St. Magnus Bay.

—— *elegans* (Leach) = *Ophiocoma neglecta*, Forbes. Tide-marks, to 40 fathoms.

—— *Ballii* (Thompson) = *Ophiocoma Ballii* and *Goodsiri*, Forbes. Common on hard ground in deep water, delighting to nestle in crevices of stones, shells, and corals.

Ophiopeltis securigera, Düb. & Koren. Added to the British fauna in 1861, when a single specimen was dredged on the Haddock-ground, about 5 miles north of Whalsey Lighthouse, in 40 fathoms.

Ophiocoma nigra (Müller) = *Ophiocoma granulata*, Forbes.

Ophiopholis aculeata (Müller) = *Ophiocoma bellis*, Forbes. Low water to 170 fathoms.

Ophiura lacertosa (Pennant) = *Ophiura texturata*, Forbes.

—— *Sarsii*, Lütken. In 80–100 fathoms, 40 miles east of Whalsey Skerries, in 1861, and subsequently procured 20–25 miles north of Unst.

—— *albida*, Forbes. Very common. A slender variety in St. Magnus Bay.

—— *affinis*, Lütken, = *Ophiura Normani*, Hodge. Haddock-ground to the north of Whalsey Skerries; 5–10 miles east of Balta, and very abundant in company with *Ophiura lacertosa*, *albida*, *squamosa*, *Amphiura filiformis*, *Chiajii*, &c., on soft mud, in 30–60 fathoms, St Magnus Bay.

—— *squamosa*, Lütken. Two fine specimens, dredged 1867, in about 60 fathoms, St. Magnus Bay.

Order ASTEROIDEA.

Astropecten irregularis (Pennant) = *Asterias aurantiaca*, Forbes.

—— *acicularis*, Norman. Living gregariously on the Out Skerries Outer Haaf, in 80–100 fathoms.

Luidia Savignii (Audouin) = *Luidia fragilissima*, Forbes. Fishing-boats from Middle Haaf, Out Skerries, 1861; also St. Magnus Bay, 1867.

—— *Sarsii*, Düben & Koren. This smaller five-armed species would appear for the most part to be an inhabitant of deeper water than its congener, and is much more common in the Shetland seas.

Archaster Parelii (Düb. & Koren). The first British specimen procured in 1864, in 100 fathoms, to the north of Unst; a second from near the same ground in 1867, in 170 fathoms.

Palmipes placenta (Pennant). A southern species which attains its northern limit in Shetland, where it seems widely diffused, though numerically scarce; 15–100 fathoms.

Solaster papposus (Linn.).

—— *endeca* (Linn.).

Porania pulvillus (Müller) = *Goniaster Templetoni*, Forbes. Scarce.

Goniaster phrygianus (Parelius) = *G. equestris*, Forbes. Not uncommon in deep water.

Var. *aculeatum* = *Astrogonium aculeatum*, Barrett, Ann. Nat. Hist. 2nd ser. vol. xx. p. 47, pl. iv. fig. 4. Two specimens of this well-marked variety, in which the tubercles of the upper marginal plates are nearly or quite obsolete, were found in 75–100 fathoms, off Unst, in 1864.

Cribrella sanguinolenta (Müller). Very common, and besides the ordinary form there are found two very distinct varieties.

Var. *curta*, which has the rays much shorter, broader, and flatter than in the type, and their texture much less firm. It is of a pale yellow colour, and rarely exceeds 2 inches in diameter. Found between tide-marks in Balta Sound.

Var. *abyssicola*. Has the rays produced, very slender, well rounded, and very firm. The paxillæ, especially those of the under surface, are most distinct and more separated from each other than usual, and the individual spines have their apices more distinctly and deeply trifid. Colour a rich saffron-yellow; greatest diameter $2\frac{1}{2}$ inches. Dredged in very deep water.

Stichaster roseus (Müller). Deep water, rather local.

Asterias glacialis, Linn. Often brought up on the hooks of the long lines, from the Middle Haaf, Out Skerries.

—— *Mülleri* (Sars). Added to the British fauna in 1861, when this pretty species was dredged off the Whalsey Skerries. It is very local.

—— *rubens*, Linn.

—— *violacea*, Müller.

—— *hispida*, Pennant. I am inclined to think that this and the two preceding must be united. *A. hispida* was taken under stones between tide-marks at the Out Skerries.

Order ECHINOIDEA.

Echinus esculentus, Linn. = *E. sphæra*, Forbes. Between tide-marks and in the laminarian and coralline zones.

Var. *tenuispina*. An *Echinus* was found in 1863 which must be regarded, I think, as a remarkable deep-water variety of *esculentus*. In form it is very high in proportion to its breadth, and the diameter is not at all greater below than above. The whole outline is perfectly free from any appearance of angularity in any part, and the spines are remarkably slender and delicate. It was brought up from a hard bottom 25–30 miles north of Unst, in 110 fathoms, and has a totally different appearance from the shallow-water forms of the species.

—— *Flemingii*, Ball. Outer Haaf, frequent; but the specimens smaller and also wider in proportion to the height than those from the south. One of the largest Shetland specimens measures three inches high and four wide.

—— *miliaris*, Leske. Common, tide-marks and Voes, and also in deep water.

—— *norvegicus*, Düben & Koren, Öfversigt af Skandinav. Echinodermer, p. 268, pl. ix. figs. 33–39. Gregariously abundant; in immense profusion on the Outer Skerries Haaf, 40 miles east of Whalsey Lighthouse; comparatively scarce on the Unst Haaf; St. Magnus Bay frequent. The bulk of specimens procured do not exceed three-fifths of an inch in diameter; one specimen, however, measures $1\frac{3}{10}$ inch. The spines are generally more or less of a green colour; but a beautiful variety also occurs in which they are vermilion-red, tipped with white.

Toxopneustes Dröbachiensis (Müller) = *Echinus Dröbachiensis*, Müller, Zool. Dan. Prodrom. p. 235, = *Echinus neglectus*, Forbes, Brit. Starfishes, p. 172. Not common, dredged at the northern entrance to Bressay Sound.

—— *pictus*, n. sp. Ambulacral pores in 4 or 5 pairs; ambulacral plates with one primary and many very small tubercles. Interambulacral plates also with only a single primary and numerous very small tubercles. Spines banded red and white. Diameter of a large specimen $1\frac{1}{2}$ inch. In deep water, Shetland Haaf, scarce, and dredged in 40 fathoms, near the Ferne Islands, on the Northumberland coast. It is also among the Echinodermata dredged by Messrs. Carpenter and Thomson in the 'Lightning' expedition during the past autumn in lat. 60° 28′ N. long. 6° 54′ W. in 500 fathoms, stones and mud, and a temperature of 32°.

Distinguished at a glance from *Dröbachiensis* by its more slender spines and their coloration, which in the latter species is green or purple, or a mixture of those two colours and white. When the spines are cleared off, the shell is found to differ in having only one primary tubercle to each interambulacral plate, while in *Dröbachiensis* there are

three or four tubercles much larger than the rest, the central one being only slightly larger than the lateral.

Brissopsis lyrifera (Forbes)=*Brissus lyrifer*, Forbes, British Starfishes, p. 187, =*Brissopsis lyrifera*, Sars, Oversigt af Norges Echinodermer, p. 96. On the Unst and Whalsey Skerries Haafs; also in St. Magnus Bay.

Echinocardium cordatum (Pennant)=*Amphidotus cordatus*, Forbes, British Starfishes, p. 190, =*Echinocardium cordatum*, Gray, List Brit. Anim. in Brit. Mus. Radiated Animals, p. 6. Only two or three specimens observed, probably because our dredging was almost wholly confined to deep water.

—— *pennatifidum*, Norman,=*Amphidotus gibbosus*, Barrett, Ann. Nat. Hist. 2nd ser. vol. xix. (1857), p. 33, pl. vii. fig. 2 (but not *A. gibbosus* of Agassiz).

This species is certainly not *A. gibbosus* of Agassiz. It is widely different from *E. cordatum*, but closely allied to *A. ovatum*, than which it is much larger and different in many particulars. The name I propose for it is in allusion to the beautiful pennatifid pedicellariæ with which it is furnished, and which are wholly unlike those of *E. ovatum*. The specimen procured by Barrett was "dredged in 25 fathoms on the south side of Bressay Island, Shetland, on a coarse sandy bottom." I have myself seen three specimens of the species from as many different localities, one dredged by myself in 1867 in St. Magnus Bay, Shetland, another procured by Mr. D. Robertson in the Clyde district, and the third obtained by Mr. Hodge off the Northumberland coast.

—— *ovatum* (Leske)=*Amphidotus roseus*, Forbes, British Starfishes, p. 196. Very common in deep water, 40–140 fathoms.

Spatangus purpureus (Müller). Common in deep water, down to 100 fathoms.

—— *meridionalis*, Risso, Hist. Nat. de l'Europe Méridionale, vol. v. (1826) p. 280; Sars, Middlehavets Littoral Fauna (1857), p. 118.

Very near to *S. purpureus*, but the shell much higher and more tumid dorsally, and the hinder portion more produced and narrower in comparison with the anterior extremity. The colour is much deeper, being of a very deep purple hue in every part; the larger spines of the interambulacral areas are not conspicuously larger and longer than the rest; the ambulacral fascioles are very narrowly lanceolate, four and a half to six times as long as broad, and thus much longer in proportion to their breadth than in *S. purpureus*, in which they are from twice and a half to thrice and a half or, very rarely, four times as long as broad*. The following give the respective dimensions of the parts in two specimens of the same length:—

	Long.	Wide.	High.	Fasciole long.	Fasciole wide.
	inches.	inches.	inches.	inch.	inch.
S. meridionalis	$3\frac{3}{4}$	$3\frac{4}{10}$	$2\frac{1}{10}$	$1\frac{7}{20}$	$\frac{5}{20}$
S. purpureus	$3\frac{3}{4}$	$3\frac{3}{10}$	$1\frac{8}{10}$	$1\frac{3}{20}$	$\frac{7}{20}$

The specimens measured were selected at random from a number, merely as being of exactly the same length, and thus calculated to give a fair idea of the specific differences.

* These measurements are taken from one of the anterior fascioles, and give the extreme breadth and height to the outside edge of the pores.

The discovery of this species in the Shetland sea is of very high interest. It is one of several instances of large conspicuous Mediterranean species turning up in the great depths of these northern waters, and which as yet are unknown at intermediate localities. *S. meridionalis* was dredged in 100–140 fathoms, 25–35 miles N.N.W. of Burrafirth Lighthouse, in company with *Cidaris papillata*, *Archaster Parelii*, *Normania crassa*, *Isodictya laciniosa*, *Raphioderma coacervata*, &c.

Echinocyamus angulosus, Leske, = *Echinocyamus pusillus*, Forbes, British Starfishes, p. 175. Common.

Echinarachnius placenta, Gmelin; Fleming, British Animals, p. 479; Forbes, British Starfishes, p. 178. "Isle of Foulah, very rare, Professor Jameson" (Fleming).

Order HOLOTHUROIDEA.

Psolus phantapus (Linn.). Frequent. The young of this species has been mistaken by British naturalists for *P. squamatus* of Scandinavian authors, a species which, though several times recorded, has not yet been found in the British seas.

Psolinus brevis, Forbes & Goodsir. "Discovered by Mr. Goodsir and myself in the Shetland seas, adhering to the stems of Laminariæ" (E. Forbes). I believe this genus and species to be founded on the young of a *Cucumaria*.

Cucumaria frondosa (Gunner). Occurs in marvellous abundance in one particular part of Bressay Sound. "Peter," who was Forbes's dredger, was indeed true to his word when he stated to me no man knew as he did where the "Puddings" were. The contents of the dredge on the very first haul was a sight not soon to be forgotten. It was literally filled with *C. frondosa*. There rolled out upon the deck thirty or more of these huge, deep purple, smooth, slimy Holothurians, measuring from 10 to 18 inches long, in every state of expansion and contraction, evidently greatly discomposed at their novel situation, and in their hurry to withdraw their much-branched tentacles and make things as snug as they could, squirting out streams of water from their capacious maws.

—— *fucicola* (Forbes & Goodsir). The type specimens were found not uncommonly "in Bressay Sound, Shetland, in 7 fathoms water, adhering to the stems of Laminariæ," and thus in the same locality with *C. frondosa*. Von Düben and Koren (Öfversigt af Skandinav. Echinod. p. 294) referred this species to the young of *C. frondosa*, and their synonymy has been copied by all subsequent writers without inquiry. But the young of *C. frondosa* is like the adult, in that "corpus, collum et pedum latera teguntur *granulis* calcareis, irregularibus, difformibus, *nunquam perforatis*," which is not the case with *C. fucicola*. Specimens of this species, procured by myself in the typical locality, have the skin supplied with calcareous plates, which are very irregular in form and size, but when fully developed are nearly round, rather longer, however, than broad, and perforated with as many as 30–40 holes. The sides of the feet are likewise furnished with the irregular-shaped, elongated, perforated plates common in this position in the different species of the genus; but these *feet-spicules* I have also observed sparingly present in the young of *C. frondosa*, though in the passage above quoted Düben and Koren deny their existence.

—— *fusiformis* (Forbes & Goodsir). Forbes, British Starfishes, p. 219, = *Cucumaria elongata*, Von Düben & Koren, Öfversigt af Skandinav.

Echinod. p. 301, pl. xi. fig. 56 *b*, and pl. iv. figs 14 A & 14 B; Sars, Middlehavets Littoral Fauna, p. 132, pl. ii. figs. 44–48; Oversigt af Norges Echinodermer, p. 101; Alder, Trans. Tyneside Nat. Field Club, vol. iv. p. 43, pl. ii. figs. 3, 4. Common, more particularly so in St. Magnus Bay.

Cucumaria Hyndmanni (Thompson). Common in deep water.

—— *lactea* (Forbes & Goodsir) = *Ocnus lacteus*, Forbes, British Starfishes, p. 231, = *Cucumaria lactea*, Von Düben & Koren, Öfversigt af Skandinav. Echinod. p. 297, pl. xi. fig. 55, and pl. iv. figs. 3–7. Common.

Thyonidium commune (Forbes & Goodsir) = *Cucumaria commune*, Forbes, British Starfishes, p. 217 (but not *Thyonidium commune*, Von Düben & Koren, Öfversigt af Skandinav. Echinod. p. 305, pl. xi. fig. 51, and pl. iv. figs. 18–23).

A single specimen in St. Magnus Bay, 1867. In this species there are spicules present in the skin, and those of the tentacles are of entirely different structure from those described and figured by Von Düben and Koren in the Scandinavian species, for which I would propose the name *Thyonidium Dübeni*. In *T. commune* the skin is covered with table-formed spicules, which have the lid round, or nearly round, with an unusually even rim, and the perforations numerous, very small and round; the legs are four, connected at the foot, and each there divided. The tentacles, instead of being covered with spicula of considerable size, as in *T. Dübeni*, have only very small spicules imbedded in their substance, of the same character and nearly the same form as those of *Thyone fusus*, but of still smaller size.

—— *hyalinum* (Forbes) = *Cucumaria hyalina*, Forbes, British Starfishes, p. 221, = *Thyonidium pellucidum*, Von Düben & Koren, Öfversigt af Skandinav. Echinod. p. 303, pl. xi. fig. 57, and pl. iv. figs. 15–17 (but not *Holothuria pellucida*, Vahl, Zool. Dan. pl. cxxxv., which is *Chirodota pellucida*, Sars, Oversigt af Norges Echinod. p. 124, pls. xiv.–xvi., = *Chirodota lævis*, Lütken, Grönl. Echinod. p. 16). Not rare on the Haaf; also in St. Magnus Bay, and the Whalsey Haddock-ground.

Thyone fusus (Müller) = *Holothuria fusus*, Müller, Zool. Dan. pl. x. figs. 5, 6, = *Holothuria papillosa*, Abildgaard, Zool. Dan. pl. cviii. fig. 5, = *Thyone papillosa*, Forbes, British Starfishes, p. 233, = *Thyone fusus*, Von Düben & Koren, Öfversigt af Skandinav. Echinod. p. 308, pl. xi. fig. 52, and pl. v. figs. 42–48.

Far from common; Whalsey Skerries Haddock-ground, and St. Magnus Bay.

—— *raphanus*, Von Düben & Koren, Öfversigt af Skandinav. Echinod. p. 311, pl. xi. figs. 58, 59, and pl. v. figs. 49–55; Sars, Oversigt af Norges Echinod. p. 112.

Common in deep water.

—— *elegans*, n. sp. Length 1–2 inches. Body smooth; skin thin, very delicate, totally devoid of all calcareous imbedded spicula; feet numerous, but not crowded, scattered all over the body, their sides without spicula, but a large round spiculum at the extremity. This spiculum has round perforations in the centre, exterior to these a circle of large radiating wedge-shaped openings, the spaces between them very narrow; and exterior to these again, and close within the edge, a few small perforations, the length of which is in the opposite direction to that of the radiating openings, each of them forming a minute segment of a semicircle. Tentacula 10 (8 long and 2 very short), completely clothed in a

scaly investiture of irregular-shaped cribriform calcareous plates. Found in St. Magnus Bay, and also on the Balta Haddock-ground.

Synapta digitata (Montagu) = *Chirodota digitata*, Forbes, British Starfishes, p. 239.

A vinous-purple *Synapta*, which was taken in 1861 in 40 fathoms, about 5 miles north of the Whalsey Lighthouse, and also on the Out Skerries Outer Haaf, I cannot distinguish by any other character except colour from *S. digitata*, to which, therefore, I assign it as a variety.

—— *inhærens* (Müller) = *Holothuria inhærens*, Müller, Zool. Dan. pl. xxxi. figs. 1–7; Von Düben & Koren, Öfversigt af Skand. Echinod. p. 322, pl. v. figs. 56–62; Woodward & Barrett, Proc. Zool. Soc. 1858, p. 363. St. Magnus Bay, 1867; two or three specimens.

Class ACTINOZOA.

In the Zoantharia the arrangement of Gosse's 'History of British Sea Anemones and Corals' is followed, and in the Alcyonaria Johnston's 'British Zoophytes.'

Order ZOANTHARIA.

Actinoloba dianthus (Ellis). In extraordinary profusion in the caves at Burrafirth; also under rocks between tide-marks.

Sagartia troglodytes (Johnston). In crevices of rocks between tide-marks to the south of Lerwick.

—— *viduata* (Müller). "Common, low water to 15 fathoms, Out Skerries, Unst, and Dourie Voe, 1864" (*fide* Peach in litt.).

Adamsia palliata (Bohadsch). Haddock-grounds, common.

Actinia mesembryanthemum, Ellis & Sol.

—— *intestinalis*, Fleming. An obscure species. Fleming says of it, "It adheres to rocks at low-water mark, Zetland" (Johnston, Brit. Zooph. p. 219).

—— *vermicularis*, Forbes. "Dredged in 50 fathoms by Mr. M'Andrew and myself between Sombro' Head (Zetland) and Fair Island; also in 80 fathoms, west of Zetland," Professor E. Forbes (Johnston, Brit. Zooph. p. 222, pl. xxxviii. figs. 2–5).

Bulocera Tuediæ (Johnston). A very fine specimen on the Haddock-ground to the north of the Out Skerries in 40–50 fathoms, and another off Unst The detached tentacles are much more frequently met with.

—— *eques*, Gosse. A magnificent specimen dredged in 1863 in 80 fathoms to the north of Unst, and again obtained by Mr. Peach in 1864 near the same place, in 100 fathoms.

Tealia digitata (Müller). Very abundant on the Outer Skerries Haaf, attached to shells of the rarest univalve Mollusca, *Fusus Islandicus* (true), *F. Berniciensis*, *F. Norvegicus*, *Buccinopsis Dalei*, as well as to those of the more common *Fusi*, and of the deep-water form of *Buccinum undatum*.

—— *crassicornis*, Müller.

Stomphia Churchiæ, Gosse. In 110 fathoms, sandy ground, on the Outer Haaf off Unst, 1864 (*fide* Peach), and St. Magnus Bay, 1867.

Arachnactis albida, Sars. "Abundantly in the towing-net, 1862" (Allman in litt.).

Corynactis viridis, Allman. Very local, on the spot between tide-marks, Out Skerries, and in about 10 fathoms. Mr. Peach tells me he found it in 1864 on a stone dredged in 100 fathoms off Unst.

Zoanthus incrustatus (Düben & Koren) = *Dysidea papillosa*, Johnston, Brit. Zooph. p. 190 partly and woodcut (not pl. xvi. figs. 6, 7), = *Epizoanthus papillosus*, Gray, Proc. Zool. Soc. 1867, p. 237, = *Zoanthus Couchii*, var. *diffusa*, Gosse, Brit. Sea Anem. p. 298, pl. ix. fig. 10, = *Zoanthus Couchii* (partly), Holdsworth, Ann. Nat. Hist. 3rd ser. vol. iv. 1859, p. 153, = *Mammillifera incrustata*, Düben & Koren, Öfversigt af K. Vet. Akad. Forh. 1844, p. 115; Sars, Reise i Lofot. og Finm. p. 142; and Forh. ved Skand. Naturf. Möde i Kjöbenh. 1860, p. 691, = *Zoanthus incrustatus*, Sars, Bemærk. over norske Cœlenterater (Videnskabs Forhandl. Christ. 1860), p. 2.

This species is well described by Sars, and is certainly, I think, distinct from *Z. Couchii*. Johnston described it as a sponge, including with it the form which he subsequently redescribed as an Actinozoon under the name *Zoanthus Couchii*. Both these names, therefore, cannot be retained, and that of Düben and Koren must be adopted for the present species. It is found in immense profusion 5–8 miles east of Balta in 40–50 fathoms, inhabited by *Pagurus lævis*; also in St. Magnus Bay.

—— *anguicoma*, n. sp. Cœnœcium coating sponges, on which it creeps in strip-like bands, from which at various intervals (generally very short) arise the polyps; column 3–5 times as high as broad, slightly expanded above, external surface of summit with about 18 radiating corrugations. Tentacles in two rows, about 34, very long and extensile, more than equal diameter of disk when fully expanded, gradually attenuating to very slender points. Cuticle with sand imbedded in the surface, but not very firm. Colour pinkish white.

Living on the Sponges, *Phakellia ventilabrum* and *robusta*, *Normania crassa*, *Oceanapia Jeffreysii*, &c., in very deep water, 110–170 fathoms, 20–25 miles N.N.W. of Burrafirth Lighthouse.

Certainly distinct from the last, which has the tentacles very short and rarely extended beyond the mouth; indeed I question if they ever are. I have watched the species alive, but have never seen them protruded to any extent; and Sars says of them, "Pars protractilis polyperum tentaculis munita 36–40 biserialibus, alternantibus, elongato-conicis, acuminatis, lævibus (haud verrucosis) superioribus longitudine dimidiam partem diametri disci oralis æquantibus, inferioribus brevioribus." In *Zoanthus anguicoma*, on the contrary, they are long, slender, and very extensile, and a colony of the species with the polyps expanded is a very pretty sight.

Sidisia Barleei, Gray, Proc. Zool. Soc. 1858, p. 532, pl. x. fig. 6, and id. ibid. 1867, p. 237.

Taken abundantly in company with *Zoanthus incrustatus*, of which I was at one time inclined to consider it a variety; but more careful examination and dissection has convinced me that there are certain distinctions between the two besides the fact of *Sidisia* being a free-living, unattached form. Whether those distinctions are specific or *sexual* (which, I think, may be the case), a careful examination of the living animal must hereafter determine.

Caryophyllea Smithii (Stokes). The variety *borealis*, Fleming (Brit. Anim. p. 509; Johnst. Brit. Zooph. p. 195), occurs in many places in extraordinary abundance on the Shetland Haaf. It ordinarily attaches itself to the shells of *Ditrupa*, but sometimes on stones, and then the base is generally broader, and the coral approaches more closely to the ordinary littoral form. Although I have traced this species over some hundred

square miles of sea-bottom, the great mass of the specimens procured are dead; but on one occasion, about 10 miles east of Balta, in 70 fathoms, the dredge came up containing literally thousands of living Caryophylleæ.

Paracyathus thulensis, Gosse. The type specimen was "dredged by Dr. Howden off Ord Head, in Bressay Sound, Shetland, in 30–40 fathoms, on a bottom of small stones, to one of which it was attached" (Gosse).

Ulocyathus arcticus, Sars. Forty miles east of Whalsey Lighthouse, in 80–100 fathoms, sandy ground, 1861; and one specimen 70–100 fathoms, Unst Haaf, 1864.

Lophohelia prolifera (Linn.). Besides the specimen in the Newcastle Museum (Johnst. Brit. Zooph. p. 251) a second fine Shetland example is now in the British Museum, which was procured some years ago by Dr. Edmonston from the Unst fishermen, and by him given to Mr. Jeffreys, who presented it to the British Museum.

Order ALCYONARIA.

Pennatula phosphorea, Linn. In great profusion, in 30–60 fathoms, in St. Magnus Bay, on a very muddy bottom; an occasional specimen now and then taken elsewhere.

Virgularia mirabilis (Linn.). On Haddock-grounds, frequent.

Gorgonia pinnata, Linn. A specimen in British Museum. "Zetland, E. Forbes, Esq. Presented by G. Johnston, M.D." (Cat. Brit. Radiated Anim. p. 56).

Primnoa lepadifera (Linn.). "Coasts of Shetland, Jameson" (Johnston, Brit. Zooph. p. 171).

Alcyonium digitatum, Linn.

—— *glomeratum*, Hassall. An orange *Alcyonium* from a cave at Hillswick seems to be referable to this. "Rocks, Out Skerries and Balta Sound" (Peach in litt.).

Rhizoxenia catenata (Forbes). Dourie Voe, and 1 mile N.E. of Whalsey Lighthouse; also off Balta. This is the *Sarcodictyon catenata* of Johnston.

Order CTENOPHORA.

Idyia cucumis (Fabr.). Frequent, towing-net.

Class HYDROZOA.

All existing British works are now so far in arrear that I could not with any degree of satisfaction follow the arrangement given in them. At my request, therefore, Mr. Hincks has kindly supplied me with a MS. copy of the classification which he will propose in his forthcoming work on the Hydroida, and this I have adopted in the following Report.

Order LUCERNARIADA.

Aurelia aurita (Müller).

Cyanea capillata (Lamk.).

Lucernaria quadricornis (Müller). On Fuci at low water, Bressay Sound, and Unst.

—— *auricula*, O. Fabr. "Tide-marks, on weeds, Out Skerries, found by Miss Jeffreys" (Peach in litt.).

Carduella cyathiformis (Sars). Professor Allman tells me that he found this species in 1862.

Order GYMNOCHROA.

Hydra viridis, Linn. In ponds and weedy lakes.

Order THECAPHORA.

Hydrallmania falcata (Linn.).
Plumularia pinnata (Linn.).
—— *helecioides*, Alder. Found by Mr. Barlee in 1858 (*fide* Alder, Ann. Nat. Hist. Feb. 1860, in note under *Camp. fastigiata*).
—— *setacea* (Ellis). Not common.
—— *Catharina*, Johnston. In great abundance, 40–73 fathoms, 5–10 miles east of Balta; also Dourie Voe, &c.
—— *frutescens* (Ellis & Sol.). Frequent, but the specimens usually small, Middle and Outer Haafs, 40–80 fathoms.
Aglaophenia myriophyllum (Linn.). Not uncommon, and often very fine.
Antennularia antennina (Linn.). Rare in Shetland, while the next is common.
—— *ramosa* (Lamx.).
Thuiaria thuia (Linn.). Frequent in about 40–50 fathoms.
—— *articulata* (Pallas). Rare, Middle Haaf.
Sertularella Gayi, Lamx. Common, Middle Haaf.
—— *polyzonias* (Linn.). Common.
—— *tenella* (Alder). Parasitic on *Tubularia indivisa*.
—— *rugosa* (Linn.). Creeping on sponges, tide-marks, abundant in Halse Hellyer, Burrafirth.
Diphasia rosacea (Linn.). Off Balta Sound, and in the Burrafirth caves.
—— *alata*, Hincks. Dredged one mile north of Whalsey Lighthouse, 40 fathoms, and also to the north of Unst.
—— *pinaster* (Ellis & Sol.) ♂ = *S. Margareta*, Hassall ♀. Common in 40–80 fathoms.
—— *tamarisca* (Linn.). Frequent, 40–90 fathoms.
—— *fallax* (Johnston). Rare, 1861.
Sertularia pumila, Linn. At low water, common on *Fuci*.
—— *abietina*, Linn.
—— *filicula*, Ellis & Sol. "Barlee, 1858" (*fide* Alder in litt.); "50–100 fathoms, rare, Out Skerries and Unst, 1864" (Peach in litt.).
—— *gracilis*, Hassall. Found in 1861, the exact habitat forgotten.
—— *operculata*, Linn.
—— *argentea*, Ellis & Sol. Lerwick Sound, and off Balta.
—— *cupressina*, Linn. Balta Sound and Burrafirth caves, not common, and small.
Halecium halecinum (Linn.).
—— *Beanii*, Johnston. Frequent.
—— *labrosum*, Alder. A fine specimen procured by Mr. Barlee in 1858, and again taken by myself in 1861, in deep water, to the north of Unst.
—— *muricatum* (Ellis & Sol.). A fragment procured by me in 1861 off Unst, and submitted to Mr. Alder, was thought by him to be referable to this species, although, as it did not bear any gonophores, some doubt attaches to the identification.
Salacia abietina (M. Sars) = *Grammaria ramosa*, Alder. The genus *Salacia*, Lamx., takes precedence of *Grammaria*, Stimpson.

Frequent, 40 fathoms, Middle Haaf, and a little to the north of Whalsey Lighthouse.

Filellum serpens (Hassall) = *Reticularia serpens.* The generic title *Reticularia* being preoccupied, Mr. Hincks substitutes *Filellum* for it. Creeping on the stems of Sertulariæ, &c., in the Burrafirth caves.

Lafoëa dumosa (Fleming).

—— *fruticosa,* Sars = *Campanularia gracillima,* Alder. Rare, Outer Haaf, off Whalsey Skerries, and 5–8 miles off Balta, 40–50 fathoms.

Calycella syringa (Linn.). "Shetland, 1858, Barlee" (*fide* Alder in litt.).

—— *fastigiata,* Alder, Ann. Nat. Hist. 3rd ser. vol. v. 1860, Feb. pl. v. fig. 1. Described from specimens procured by Mr. Barlee in 1858; again found by myself in 1863 and 1867, creeping on the stems of the larger Hydrozoa.

Cuspidella humilis, Hincks, Ann. Nat. Hist. Oct. 1866, p. 298. Found by Mr. Hincks and myself on stems of Zoophytes.

—— *grandis,* Hincks. "A new species which has occurred in some dredgings from Connemara of G. S. Brady's, and in Shetland, *teste* Mr. Alder. I do not know the history of the specimens, but you know the accuracy his labellings" (Hincks in litt.).

Campanularia flexuosa (Hincks) = *Laomedea flexuosa.* Common, between tide-marks, on *Fuci.*

—— *neglecta* (Alder). Rare, Unst.

—— *volubilis* (Linn.). On Laminariæ, in Bressay Sound, in 3–5 fathoms.

—— *integra* (Macg.). Parasitic on *Tubularia indivisa,* at extreme low water, in the Burrafirth caves.

—— *verticillata* (Linn.) Rare, found in 1861.

—— *Hincksii,* Alder. Identified by Mr. Alder among the Zoophytes procured by Mr. Barlee in 1858.

Clytia Johnstoni (Alder). Bressay Sound and Unst.

Obelia longissima (Pallas). 5–10 miles east of Balta, in 40–73 fathoms.

—— *geniculata* (Linn.). I insert this species with doubt. In the MS. list of species procured in 1861, I entered "*Laomedea geniculata,* var." as common on Laminariæ in Bressay Sound. I have not specimens preserved, and they may perhaps have belonged to one of the forms lately elevated to specific rank.

—— *gelatinosa* (Pallas). The specimen from which Johnston's plate xxvii. was drawn was procured by Dr. Coldstream in Shetland (*vide* p. 105).

—— *plicata,* Hincks. "One of the new species I met with in the large bottle of Shetland Hydrozoa sent me by Mr. Jeffreys. The precise place was not marked on it. This *Obelia* is a very splendid one" (Hincks in litt.).

Gonothyræa Loveni, Allman. Once found, 1861.

—— *hyalina,* Hincks, Ann. Nat. Hist. Oct. 1866, p. 297. "Profusely investing *Tubularia, Halecium,* &c., from Shetland. I am indebted to J. Gwyn Jeffreys, Esq., for my specimens" (Hincks, *l. c.*).

Order ATHECATA.

Clava multicornis (Forskål). Abundant between tide-marks, Lerwick, on *Fuci*; also at Balta Sound.

—— *squamata* (Müller). With the last at Balta Sound, 1867. Determined for me by Professor Allman.

—— *cornea,* S. Wright. With *C. multicornis,* at Lerwick, in 1861. Examined and named by Mr. Alder. I have not the specimens at hand to reexamine; and as the members of this genus have been much mis-

understood, it is probable that the specimens here called *cornea* are referable to *squamata*.

Clava diffusa, Allman, Ann. Nat. Hist. 3rd ser. vol. xi. 1863, p. 8; Brit. Assoc. Rep. 1862 (1863), p. 101. "Rock-pools, at low spring tides, Out Skerries" (Allman).

Tubiclava cornucopiæ, Norman, Ann. Nat. Hist. 3rd ser. vol. xiii. p. 82, pl. ix. figs. 4, 5, =*Merona cornucopiæ*, id. ibid. 3rd ser. vol. xv. p. 262. On *Astarte sulcata* and *Dentalium entale*, 20 miles north of Unst, in 80–100 fathoms, 1863; St. Magnus Bay, and 5–8 miles east of Balta, in 40–50 fathoms on *Dentalium*, 1867.

Hydractinia echinata (Fleming).

Podocoryne areolata (Alder)=*Hydractinia areolata*, Alder, Trans. Tyn. Nat. Field Club, vol. v. p. 225. pl. ix. figs. 1–4, =*Rhizocline areolata*, Allman, Ann. Nat. Hist. 3rd ser. vol. xiii. (May, 1864). A specimen investing the shell of *Natica Grœnlandica* found in 1863, 10 miles east of Balta, in 73 fathoms.

Coryne pusilla, Gærtner=*Sarsia tubulosa*, Forbes, Naked-eyed Medusæ (the gonosome), *fide* L. Agassiz.

Tide-marks, Balta Sound, 1867; the ordinary form, and also a slender variety of the species. Norman

"—— *nutans*, Allman, n. sp. *Trophosome*—Hydrocaulus attaining a height of about 4 lines, much branched; branches subalternately disposed, deeply and distinctly annulated, the annulations of hydrocaulus becoming less distinctly marked towards the base. Polypites depressed on one side of the stalk, so as to assume a nutant posture, ovate, with about 15 tentacula. *Gonosome* unknown.

"Our ignorance of the gonosome renders the allocation of the present hydroid in the genus *Coryne* a merely provisional one . . . . Its trophosome resembles that of *Coryne pusilla*, but is smaller, while the hydranths droop upon their stalks in a characteristic way not noticeable in *C. pusilla*" (Allman in litt.). Found in 1863 in the caves at Burrafirth, especially in Halse Hellyer, where it lives abundantly, with the base of the hydrocaulus immersed in sponges which coat the sides of the cave from extreme low-water mark to about half-tide.

—— *vermicularis*, Hincks, Ann. Nat. Hist. Oct. 1866, p. 296. "Shetland, from deep water" (Hincks).

—— *ramosa*, Ehrenberg. Procured in 1863; the specimen identified by Mr. Alder.

Syncoryne eximia (Allman). "Shetland, 1864, Peach" (*fide* Alder in litt.).

Eudendrium rameum (Pallas).

—— *ramosum* (Linn.).

—— *annulatum*, Norman, Ann. Nat. Hist. 3rd ser. vol. xiii. p. 83, pl. ix. figs. 1–3. The type specimens procured in 1863 in "Buness Hall," one of the caves of Burrafirth, at extreme low water, spring tides.

—— *vaginatum*, Allman, Ann. Nat. Hist. 3rd ser. vol. xi. (1863) p. 10; Brit. Assoc. Rep. 1862 (1863), p. 102. "Rock-pools, extreme low water, spring tides, Shetland" (Allman); also 40–50 fathoms off Balta, 1867 (A. M. N.), the specimen determined by Prof. Allman.

Coppinia arcta, Dalyell, or *Sertularia abietina*, *Halecium halecinum*, &c. In a paper read this year (1868) at the Brit. Assoc. Meeting, Prof. Allman showed that *Coppinia* is a Tubularian and not a Campanularian.

Perigonimus minutus, Allman, Ann. Nat. Hist. 3rd ser. vol. xi. (1863) p. 11; Brit. Assoc. Rep. 1862 (1863), p. 102. "Forming a fringe round the

edge of the operculum of *Turritella communis*, dredged in Basta Voe, Shetland. Out of between twenty and thirty specimens of living *Turritella* examined, not one was free from this remarkable little Zoophyte" (Allman). Mr. Hincks tells me that he has identified this species with *Perigonimus repens*, Allman, but that Prof. Allman dissents. This being so, I think it better to retain here the name of *minutus* given to the Shetland specimen.

Garveia nutans, S. Wright = *Eudendrium* (*Corythamnium*) *bacciferum*, Allman. "Very fine, amongst a number of Zoophytes from Shetland, sent me by Mr. Busk. In the bottle containing it was also the *Coryne vermicularis*, Hincks, and *Zoanthus incrustatus*, which I am glad to see you recognize as a distinct species. I have taken the same view in my Devon Catalogue, in a note on *Cellepora edax*. I do not know the precise locality in which these things were found" (Hincks in litt.).

Dicoryne conferta, Alder. Abundant on shells, especially of *Aporrhais pes-pelecani*, dredged in 40–50 fathoms 5–7 miles off Balta, and in St. Magnus Bay.

Tubularia indivisa, Linn. In great abundance at low water, spring tides, in the Burrafirth caves, also dredged in 50–60 fathoms.

—— *bellis*, Allman, Ann. Nat. Hist. 3rd ser. vol. xi. 1863, p. 12; Brit. Assoc. Rep. 1862 (1863), p. 103. "Bottom of rock-pools at extreme low water, spring tides, Shetland" (Allman).

—— *attenuata*, Allman, Ann. Nat. Hist. 3rd ser. vol. xiv. p. 60. "Dredged from about 50 fathoms in the Shetland seas" (Allman). In 1867 I procured a *Tubularia* in some quantity 5–8 miles to the east of Balta, which, not being able to recognize, I sent to Prof. Allman to examine. He refers it to the present species, and writes: "It has certain distinctive features it is true, but nothing which I regard as sufficient to separate it from *T. attenuata*. The specimens on which I founded this species were male, while your specimens are female; and I believe that the difference in the gonosome between the two forms may be sufficiently explained by referring them to a difference of sex."

—— *coronata*, Van Ben., = *T. gracilis*, Harvey. Haddock-ground, Out Skerries and Unst.

—— *larynx*, Ellis & Sol. Caves at Burrafirth, spring tides, and 5–7 miles east of Balta, in 40–50 fathoms, on *Tubularia indivisa*.

Corymorpha nutans, Forbes & Goodsir. 5–7 fathoms in Balta Sound.

Order CALYCOPHORIDA.

Diphyes (? *appendiculata*, Eschscholtz). A beautiful *Diphyes*, the nectosacs of which were of a delicate rose-colour, occurred in profusion in the open sea, about 30 miles N.N.W. of Unst, in July 1867. Unfortunately, as I had no works with me at the time, I am unable to identify the species. The rapidity in its growth was most extraordinary; the cœnosarc of a specimen kept alive was developed nearly 3 inches in a single night.

Order PHYSOPHORIDA.

Physophora (? *borealis*, Sars, Bemærkninger over norske Cœlenterater [Videnskabs Forh. i Christiania, 1860], p. 8). Found on the same occasion with the preceding; I much regret being unable to determine the species of the first member of this very interesting order that has been observed in our seas. On the only occasion on which I saw the *Physophora*, the

sight, looking over the yacht's side, was a thing never to be forgotten. The sea was swarming with myriads of the *Physophora*, *Diphyes*, *Cydippe*, and allies, *Cyanea*, *Aurelia*, &c., and long chains of *Salpa runcinata*. Among the animals observed that evening was a Medusa (using that word in a *class* sense) which was quite unlike any genus that I am acquainted with,—a little flat plate, about the size of a threepenny piece, with very numerous long tentacles round its edge, the whole animal perfectly transparent and colourless.

NAKED-EYED MEDUSÆ.

Although the following species ought to be incorporated with and inserted in their proper places among the preceding Hydrozoa, yet our knowledge being at present confined to the gonosome, it is not possible to allocate them with any degree of precision. I have thought it better therefore to keep them together here, leaving future discoverers, who shall become acquainted with the trophosomes, to assign them their respective places. My own time in Shetland was too much taken up with other animals to allow me to study these Medusoids. The following list contains the species observed in Shetland by Forbes, as recorded in his 'British Naked-eyed Medusæ;' but I have arranged them more in accordance with our present state of knowledge, throwing them into the families and genera to which they are referred by Prof. L. Agassiz in his 'Contributions to the Natural History of the United States,' vol. iv. 1862, and by his son, Alexander Agassiz, in his 'Illustrated Catalogue of North American Acalephæ,' 1865.

Order THECAPHORA, Hincks.

Fam. OCEANIDÆ, Esch.

Genus PLATYPYXIS.

Thaumantias æronautica, Forbes. "Off Bressay, and in Hamna Voe in Papa" (Forbes).

—— *maculata*, Forbes. "Sound of Bressay, but not plentiful" (Forbes). Not hitherto observed elsewhere.

—— *globosa*, Forbes. "Very abundant in the harbours on both sides of the Shetland Isles" (Forbes). Not as yet noticed elsewhere.

—— *melanops*, Forbes. "Has hitherto occurred only in the Zetland seas, and is not very common there" (Forbes).

L. Agassiz considers the above four species to be referable to *Platypyxis*, L. Agass., or the closely allied genera *Clytia*, Lamx., or *Wrightia*, L. Agass.; but the younger Agassiz subsequently writes (Cat. North Amer. Acalephæ, p. 103), "may not the *T. gibbosa* of Forbes be a young *Halopsis*? They resemble the young of this species (*Halopsis cruciata*, A. Agass.); also *T. globosa*, and perhaps *T. pilosella*."

Genus OCEANIA, Pér. & Les. (restricted).

Thaumantias hemisphærica, Forbes. "Zetland, where they abound in the bays and harbours" (E. F.). This species is considered by L. A. to be synonymous with *Oceania phosphorica*, Péron & Les. and the *T. inconspicua*, *T. lineata*, *T. punctata*, *T. pileata*, and *T. Sarnica* are said to be probably different stages of growth only of *T. hemisphærica*.

—— *lineata*, Forbes. "Taken in the Zetland seas in 1846, but not found common" (E. F.).

—— *convexa*, Forbes. "A very common species in the Zetland seas" (E. F.). "May be a distinct species" (L. A.).

Fam. EUCOPIDÆ, Gegenb. (restricted).

Genus EUCOPE, L. Agass.

Eucope lucifera (Forbes), = *Thaumantias lucifera*, Forbes. "Zetland" (E.F.). "*Laomedea geniculata*, Gosse, Devon, pl. iv., and *Campanularia gelatinosa*, Van Ben. pl. i. & ii., may be the young of this species" (L. Agass.).

Fam. LAODICEIDÆ, L. Agass.

Genus LAODICEA, Lesson.

Laodicea stauroglypha (Pér. & Les.) = *Thaumantias* (*Cosmetira*) *pilosella*, Forbes. "Very abundant in the bays and harbours of Zetland, especially in the Sound of Bressay, where it is the most common species of the genus" (E. F.).

Fam. TRACHYNEMIDÆ, Gegenb.

Genus TRACHYNEMA, Gegenb. (*vide* A. Agass. Cat. p. 54).

Trachynema rosea (Forbes) = *Circe rosea*, Forbes; the generic name *Circe* preoccupied for a genus of Acephalous Mollusca. "The first specimen was taken by Mr. M'Andrew and myself in the Zetland seas, in August 1845, off Vella, 7 miles from land. We afterwards met with several in Bressay Sound, on the opposite coast of the mainland" (E. F.).

Order ATHECATA, Hincks.

Fam. NUCLEIFERÆ, Lesson.

Genus STOMATOCA, L. Agass.

Stomatoca dinema (Forbes) = *Saphenia dinema*, Forbes (but not Esch.), = *Saphenia Titania*, Gosse, Devon, pl. xxvi. figs. 7–9. "Near Hillswick, on the western coast of Zetland, in 1845" (E. F.).

Genus PANDEA, Less. (restricted, L. A. p. 347).

Pandea globulosa (Forbes) = *Oceania globulosa*, Forbes. "I procured two specimens of this singular *Oceania* in the Sound of Bressay, in 1835" (E. F.).

Genus TIARA, Lesson.

Tiara octona (Fleming) = *Oceania octona*, Forbes. "In the seas near the east coast of Zetland" (E. F.). "*Oceania saltatoria*, Sars, *O. turrita*, and *O. episcopalis*, Forbes, Nak. Med. pl. ii. figs. 2 & 3, are probably different stages of growth of this species" (L. Agassiz, p. 347).

—— *turrita* (Forbes) = *Oceania turrita*, Forbes. "Taken in the Zetland seas in 1845" (E. F.).

—— *episcopalis* (Forbes) = *Oceania episcopalis*, Forbes. "This beautiful Medusa was taken in the neighbourhood of the western line of bank, 40 miles from the mainland of Zetland, in the autumn of 1845" (E. F.).

Turris digitalis, Forbes. Procured by E. Forbes "in the autumn of 1845, in the Sound of Bressay." It is not, according to A. Agassiz (Cat. North Amer. Acal. p. 59), the *Medusa digitalis* of O. Fab. to which Forbes refers it. Fabricius's species is the *Trachynema digitale* of A. Agassiz. The trophosome of this genus is *Clavula* of S. Wright.

Fam. BOUGAINVILLIADÆ, Lütken.

Lizzia octopunctata (Sars). "Swarms in the bays of the eastern and western coasts of Zetland. I have not met with it elsewhere" (E. F.).

Lizzia blondina, Forbes. "First met with in the Sound of Bressay, and afterwards off Fitful Head" (E. F.).

Genus Margelis, Steenstrup.

Margelis ramosa (Dalyell)=*Tubularia ramosa*, Dalyell, and *Medusa ocilia*, Dalyell, pl. xi., =*Bougainvillia Brittanica*, Forbes. "Zetland" (E. F.).

—— *nigritella* (Forbes)=*Bougainvillia nigritella*, Forbes. "Discovered by Mr. M'Andrew and myself in the Sound of Bressay, Zetland, during the autumn of 1845" (E. F.). (*Vide* also for remarks on this genus, A. Agass. Cat. p. 157, and Allman, Ann. Nat. Hist. 3rd ser. vol. xiii. May 1864).

Fam. Tubulariadæ, Johnston (restricted).

Sarsia gemmifera, Forbes. "Several specimens in the Zetland seas, by Mr. M'Andrew and myself in 1845" (E. F.). "*Sarsia gemmifera*, Forbes, Nak. Med. pl. vii. fig. 2, and *Sarsia prolifera*, Forbes, Nak. Med. pl. vii. fig. 3, may belong to this genus (i. e. *Hybocodon*, L. Agass.), or form another distinct group" (L. A.).

Euphysa aurata, Forbes. "A very beautiful little Medusa, taken in 1835 in Bressay Sound" (E. F.).

Steenstrupia rubra, Forbes. "Hundreds of specimens secured in the bays of both sides of Zetland" (E. F.).

Genus Ectopleura, L. Agass.

Ectopleura pulchella, Forbes=*Sarsia pulchella*, Forbes. "Several specimens in Bressay Sound, Zetland, in 1845" (E. F.).

As already stated under *Coryne pusilla*, Forbes's *Sarsia tubulosa*, procured in Shetland, is the gonosome of that species according to L. Agassiz; Hincks writes to me on it, "*Sarsia tubulosa*, zooid of *Syncoryne*, perhaps *S. gravata*." (*Vide* also Allman, Ann. Nat. Hist. 3rd ser. vol. xiii. 1864, May.)

Class PORIFERA.

Dr. Bowerbank's 'Monograph of the British Spongiadæ' is used as the text-book for this Class; and the whole of my collections having been continually placed at that author's service during the preparation of his work, the species in the following list have in every case, where there was the remotest doubt, been sent for examination and determined by him, a large number of them being types of his species. In the year 1864, when I was prevented accompanying the Dredging Committee, Mr. Peach, who was of the party, paid special attention to the preservation of the sponges, and was instrumental in adding a considerable number of species to our fauna.

Order CALCAREA.

Grantia compressa (Fabr.). Common between tide-marks. The finest specimens I have ever seen taken in one limited spot at the Out Skerries. A small and very curious variety between tide-marks in Halse Hellyer, Burrafirth.

—— *ciliata* (Fabr.). On *Fuci* frequent, tide-marks. It is much to be regretted that Bowerbank in his work has transgressed the law of the British Association rules of nomenclature, strictly observed by all naturalists (except certain French writers), of affixing that author's name who first described the species. Thus he assigns this and the foregoing species to Fleming, whereas they were both characteristically described by O. Fa-

bricius in his 'Fauna Grönlandica' forty-eight years before, and similarly the next species appears as *Leucosolenia botryoides*, Bowerbank, though Ellis and Solander were the describers of the species under the name *Spongia botryoides*. A curious aggregated form occurs in company with the var. *G. compressa* in Halse Hellyer.

Leucosolenia botryoides (Ellis & Sol.). Common under stones and attached to seaweeds. Specimens of gigantic growth found in the same spot with the very large *Grantia compressa*, living attached to the underside of stones.

—— *lacunosa* (Johnston). "Shetland, 1864" (Peach, *fide* Bowerbank).

—— *coriacea* (Montagu). Common under stones, and on the sides of caves in various parts of Shetland. Abundant in Halse Hellyer, Burrafirth, where lemon-yellow and white varieties live side by side.

Leuconia nivea (Grant). "Shetland, 1864" (Bowerbank in litt.). The specimens in this and other cases thus quoted Dr. Bowerbank informs me were sent to him by Messrs. Jeffreys and Peach.

—— *fistulosa* (Johnston). Dredged in St. Magnus Bay, 30–60 fathoms.

Order SILICEA.

Geodia Zetlandica, Johnston. "Island of Foulah and Unst" (Jameson).

Pachymatisma Johnstonia, Bow. A single specimen, procured after great difficulty, and not without some danger, at the extremity of 'Will Hellyer,' Burrafirth, a cave of difficult access, except under most favourable conditions of weather.

Genus Normania, Bowerbank, n. g.

"Skeleton composed at the external surfaces of short fasciculi of siliceous spicula; in the interior, of an irregular siliceo-spicular network. Dermis furnished with ternate connecting spicula. Ovaria membranous, aspiculous.

"Type, *Normania crassa*.

"The general structure of the skeleton of the type specimen of this genus is very like that of *Pachymatisma*, but it is readily distinguished from that genus by the total absence of siliceous ovaria, and by its thin and delicate dermal system.

"The radial structure of its skeleton near the surface of the sponge, and its dermal connecting spicula, bring it somewhat into alliance with *Ecionemia*, but the total absence of a central axial column readily distinguishes it from that genus. I have named this genus after my friend the Rev. Alfred Merle Norman, the ardent and accomplished naturalist to whom I am indebted for numerous new and valuable species of British sponges."

"A genus *Normania* was established by Mr. G. S. Brady in 1866, for a section of Crustacea Ostracoda (*vide* Trans. Zool. Soc. vol. v. p. 382), but that title cannot be adopted, as the *Normania* of Brady is identical with *Loxoconcha* of G. O. Sars, which was founded a few months previously (*vide* G. O. Sars, Oversigt af Norges marine Ostracoder, 1865, and G. S. Brady, Trans. Linn. Soc. vol. xxvi. 1868, p. 432).

"*Normania crassa*, Bowerbank, n. sp. Sponge cup-shaped, sessile?; parietes stout and thick. Surfaces smooth, outer one minutely reticulated. Oscula on inner surface simple, variable in size, very numerous. Dermis thin, pellucid; outer surface furnished with a stout polyspiculous irregular reticulation; on the inner one with numerous dispersed tension-spicula large and small; spicula subfusiformi-acerate; and also with numerous large and small attenuato-stellate retentive spicula. Con-

necting spicula expando-ternate; radii attenuated, very long, shafts very short. Skeleton—fasciculi and reticulations stout and polyspiculous; rete open and irregular; spicula subfusiformi-acerate, long and large. Interstitial membranes pellucid, furnished abundantly with small subfusiformi-acerate tension-spicula, and with numerous large and small attenuato-stellate retentive spicula. Gemmules membranous, aspiculous. Colour in the dried state light grey. Habitat. Shetland, 110 fathoms (Rev. A. M. Norman). Examined in the dried state."

To this description of Dr. Bowerbank I may add that the "subfusiformi-acerate tension-spicula" are incipiently and entirely spined, and are, moreover, very frequently furnished with a central umbo.

Ecionemia compressa, Bow. Rare, in very deep water, Unst Haaf, in 1864 and 1868.

Genus Quasillina*, Norman, n. g.

Sponge consisting of a single clavate hollow body, widening upwards from the base, and rising at once from the surface of the stone to which it is attached, without any expanded basal mass. Skeleton beautifully reticulate, primary fasciculi ascending in parallel straight lines from the base, and in diverging radiating lines from a central mammæform projection at the summit of the sponge; secondary fasciculi at right angles to the primary ones. Spicula fusiformi-acuate.

Quasillina brevis (Bow.)=*Polymastia brevis*, Bow. Brit. Spongiadæ, vol. ii. p. 64. Frequent on pebbles in from 40 to 170 fathoms. It is necessary to separate this species from the genus *Polymastia*; for whereas in the latter genus several (often very numerous) fistular cloacæ arise from an expanded basal mass, which is, in fact, the body of the sponge, in *Quasillina* the entire sponge consists of a single hollow cylinder, which widens from the base upwards, and is most expanded near the summit. When compressed, a rupture always takes place between the summit of the column and the cap-formed top, which separates as a kind of lid. This lid, with its central mammæform point, its radiating primary lines of bundles of spicules, and its transverse secondary lines, reminds us strongly of the top of a basket. In all these respects the genus approaches very closely to the genus *Euplectella*, much more so than do the species of the genus *Polymastia*. The spicula are needle-shaped (acuate), swollen in the central part, and attenuated towards the "head" as well as towards the point; but they are not "acerate" as described by Dr. Bowerbank, the head end being blunt and rounded. The smaller spicules sometimes assume a slightly pin-shaped ("spinulate") form.

Polymastia bulbosa, Bow. The type specimen. "Shetland, Mr. C. W. Peach, 1864."

—— *spinula*, Bow. In 50–110 fathoms, on stones and shells. In a specimen which has but one fistula, though its basal mass is only $\frac{1}{4}$ of an inch in diameter, the fistula is no less than $1\frac{1}{4}$ inch long, but only $\frac{1}{20}$ of an inch wide. Other specimens have as many as five and six fistulæ.

—— *radiosa*, Bow. The type-specimen. "Shetland, Mr. C. W. Peach" (Bowerbank).

—— *mammillaris* (Müller). A single specimen in 1868, also procured by Mr. Barlee.

Tethea cranium (Müller). Common on the Outer Haaf, sometimes attached

* *Quasillus*, a little basket.

to stones, but more commonly growing parasitic on other sponges, especially on *Pkakellia ventilabrum.*

Tethea lyncurium (Linn.). "Shetland, 1864" (Bowerbank in litt.).

—— *spinularis*, Bow. The type specimens found on stones from 70–80 fathoms, Out Skerries Haaf.

Halicnemia patera, Bow. A very rare and remarkably interesting little sponge, found 1863 and 1864.

Dictyocylindrus virgultosus, Bow. The type specimen found in 1861 in deep water off Out Skerries.

—— *stuposus* (Ellis & Sol.). Very fine specimens found in 1867.

—— *hispidus* (Montagu). Dredged to the east of the Island of Balta, 1867.

—— *rugosus*, Bow. A fine species, very local, but, where found, abundant. Out Skerries, Outer Haaf, 70–90 fathoms, 40 miles E.S.E. of Whalsey Lighthouse.

Phakellia robusta, Bow. In 100–170 fathoms, 20–25 miles N.N.W. of Burrafirth Lighthouse. My finest specimen measures 5½ inches long and 6 in diameter, and is fan-shaped, but doubled back upon itself so as almost to form a cup. It is one of our finest species.

—— *ventilabrum* (Linn.). Very common in deep water in 50–170 fathoms, though rarely at the former depth. Unquestionably the grandest British sponge. There are two magnificent specimens in my collection. One, which spreads out at once from the base, so that the cup is hardly developed at all, and the sponge is nearly flat, measuring 13 inches long and 9 wide, but is only 3 inches high. The other takes the shape of a very deep well-formed cup, composed of many lobes, cut almost to the base of the sponge, but together forming a regular circle; this sponge is 10 inches high and as much in diameter at the summit. Proliferous specimens often occur in which many small sponges grow from the inner face of the parent.

Microciona lævis, Bow. "Shetland, Mr. Barlee" (Bowerbank). The only known specimen.

—— *armata*, Bow. "Shetland, 1864" (Bowerbank in litt.).

—— *spinulenta*, Bow. "Shetland, 1864" (Bowerbank in litt.).

—— *ambigua*, Bow. Found in 1861.

—— *atrosanguinea.* "Shetland, 1864" (Bowerbank in litt.).

" —— *simplicissima*, Bowerbank, n. sp. Sponge coating, surface irregular. Oscula simple, dispersed. Pores inconspicuous. Dermal membrane pellucid, spiculous; spicula cylindrical, long, slender, and very flexuous; rarely acerate, irregularly dispersed, numerous. Basal membrane stout, abundantly spiculous; spicula like those of the dermal membrane, very numerous and closely matted together. Skeleton—columns short and stout; spicula acute, not more than half the length of those of the dermal and basal membranes, but rather stouter. Colour milk-white in the dried state. Habitat. Shetland, 96 fathoms (Rev. A. M. Norman). Examined in the dried state." (Bowerbank MS.)

Hymeraphia vermiculata, Bow. On stones, Shetland, deep water, not uncommon.

—— *clavata*, Bow. On stones, deep water (Mr. Barlee and A. M. N.).

—— *stellifera*, Bow. Outer Haaf, on stones, 1861; on shell off Balta, 40–50 fathoms, 1863.

" —— *coronula*, Bowerbank, n. sp. Sponge coating, thin. Surface uneven; both strongly and minutely hispid. Oscula simple, dispersed. Pores inconspicuous. Dermal membrane spiculous; tension-spicula

acerate, very long and slender, flexuous, dispersed singly, or fasciculated, fasciculi frequently polyspiculous: external defensive spicula—the larger ones arising from the projection of the distal extremities of the skeleton spicula through the dermal membrane; the smaller ones attenuato-spinulate, entirely spined, basal bulb often coronulated spinously. Skeleton—spicula spinulate, very long and large, distal end usually projected through the dermal membrane. Basal membrane pellucid; tension-spicula same as those of the dermis, dispersed singly, few in number; internal defensive spicula same as those of the dermal membrane. Sarcode abundant. Colour, dried, light grey. Habitat. Shetland (Rev. A. M. Norman). Examined in the dried state."

Hymedesmia radiata, Bow. The type specimen found in 1864; again procured in 1867.

—— *Zetlandica*, Bow. The type found by Mr. Barlee, and taken by myself on stones from the Haaf, 1863.

" —— *occulta*, Bowerbank, n. sp. Sponge parasitical, coating. Surface irregular, abundantly hispid. Oscula simple, dispersed. Pores inconspicuous. Dermal membrane abundantly spiculous; tension-spicula acerate, large and long, dispersed; retentive spicula bidentate equianchorate, large and stout, numerous, dispersed. Skeleton fasciculi multispiculous; spicula very numerous, same as those of the dermal membrane with an admixture of stout fusiformi-acerate ones. External defensive spicula attenuato-acuate, size various; large ones basally spined; smaller ones entirely spined. Colour milk-white. Habitat. Shetland, 96 fathoms (Rev. A. M. Norman). Examined in the dried state."

Hymeniacidon reticulatus, Bow. "Stroma, Shetland, Mr. C. W. Peach" (Bowerbank).

—— *perarmatus*, Bow. The type specimen procured 40 miles east of the Outer Skerries in 1861.

—— *membrana*, Bow. The type specimens on the underside of stones between tide-marks, near Lerwick, 1861.

—— *mammeatus*, Bow. Two specimens in 1868.

—— *viridans*, Bow. "Shetland, 1864" (Bowerbank in litt.).

—— *lingua*, Bow. A very large species procured in very deep water, Out Skerries and Unst, in 1864 and 1867.

—— *floreus*, Bow. On roots of a *Fucus*, extreme low water, spring tides, Out Skerries, 1861.

—— *subereus* (Montagu). Not so common as *M. ficus*, to which it is very closely allied.

—— *carnosus* (Johnston). Large short-stalked specimens, of the size of a large apple, in Dourie Voe. Small specimens with the head about $\frac{1}{3}$ of an inch in diameter, elevated on a slender footstalk about an inch long, but at other times almost sessile, in 40–50 fathoms, 5–8 miles east of the Isle of Balta.

—— *ficus* (Esper.). Common, coating univalve shells, and generally inhabited by hermit-crabs, in moderately deep water.

[*Hymeniacidon gelatinosus*, Bow. Dr. Bowerbank gives the locality of the type specimens of this species as "Dourie Voe, Shetland." This is a mistake; they were from under a stone between tide-marks at Cullercoats, Northumberland. The error doubtless arose from the circumstance that at the same time there were sent to him with this species specimens of *Hymeniacidon carnosus*, which were from Dourie Voe.]

Hymeniacidon sulphureus, Bow. "Shetland, 1864" (Bowerbank in litt.).

—— *paupertas*, Bow. Parasitical on zoophytes from deep water in 1861, off Out Skerries.

Cliona celata, Grant. Common in shells.

Halichondria panicea (Pallas). The encrusting forms very abundant in caves and on stones between tide-marks. A giant specimen, in the form of a roll wrapped round the stem of a Laminaria, measures 13 inches long and 3 inches in diameter.

—— *coalita* (Grant). "Shetland, 1864" (Bowerbank in litt.).

—— *forceps*, Bow. On the Outer Haaf, off Unst, in 1864 and 1868. The "forcepiform" spicula in this species are very remarkable, and at once distinguish the species. They resemble very slender hair-pins, the bow very narrow, the pins very long, finely spinulous, and approaching each other at the points.

—— *simplex*, Bow. "Shetland, Mr. C. W. Peach" (Bowerbank).

—— *incrustans* (Esper). Abundant, coating the sides of Halse Hellyer, Burrafirth, growing side by side with *H. panicea* and *Isodictya fucorum*, the three species intermingling with each other.

—— *Dickiei*, Bow. On *Cellepora cervicornis*, dredged in deep water, 1863.

—— *Patersonii*, Bow. Rare, one specimen found in 1867.

"—— *falcula*, Bowerbank, n. sp. Sponge massive, sessile. Surface uneven, minutely spinous and reticulated. Oscula simple, dispersed. Pores inconspicuous. Dermal membrane pellucid, furnished with a stout irregular polyspiculous network. Skeleton—rete polyspiculous, very irregular and diffused; spicula fusiformi-acuate, slender and long. Interstitial membranes—tension-spicula same as those of the skeleton but smaller, few in number. Retentive spicula trenchant, contort, bihamate, stout and large, very few in number. Gemmules membranous, aspiculous. Colour in the dried state cream-white. Habitat. Shetland. Rev. A. M. Norman. Examined in the dried state."

"—— *mutulus*, Bowerbank, n. sp. Sponge sessile, massive. Surface openly reticulated. Oscula simple, very numerous. Pores inconspicuous. Dermal membrane spiculous; tension-spicula acuate, slender, very nearly as long as those of the skeleton, few in number; also tricurvato-acerate, very long and slender, nearly straight, sometimes flexuous; central curve abruptly angulated or looped, rather numerous; retentive spicula dentato-palmate, equianchorate, very minute and symmetrical, few in number. Skeleton equably reticulate; rete stout and polyspiculous; spicula subattenuato-acerate, stout and strong, moderately long. Interstitial membranes pellucid, furnished with the same forms of spicula as the dermal membrane but more sparingly. Colour in the dried state light brown Habitat. Shetland, 96 fathoms (Rev. A. M. Norman). Examined in the dried state."

—— *scandens*, Bow. The type specimen, dredged in 1861 in deep water off the Out Skerries. It is a minute species, which encrusts the stems of Sertularian Zoophytes.

—— *Batei*, Bow. "Shetland?, Mr. Spence Bate" (Bowerbank).

—— *Hyndmanni*, Bow. "Shetland, 1864" (Bowerbank in litt.).

—— *albula*, Bow. "Shetland, deep water, Barlee" (Bowerbank).

—— *inornata*, Bow. "Shetland, Mr. C. W. Peach" (Bowerbank).

Isodictya varians, Bow. "Shetland, Mr. Barlee" (Bowerbank).

—— *jugosa*, Bow. The type specimen, found in deep water off the Out Skerries.

Isodictya palmata (Ellis & Sol.). Shetland (Fleming and Jameson), and more recently in 1864 (*fide* Bowerbank).

—— *infundibuliformis* (Linn.). Common on the Haaf in 50–170 fathoms. My largest specimen measures 9½ inches in diameter across the cup, and is about 6 inches high.

"—— *laciniosa*, Bowerbank, n. sp. Sponge sessile, fan-shaped, thin. Surface uneven, laciniose, minutely hispid. Oscula and pores inconspicuous. Dermal membrane pellucid, spiculous; spicula acuate, long and slender, not very numerous; retentive spicula dentato-palmate, equianchorate, palm rather exceeding one-third the length of the spiculum, tooth terminally truncated, numerous, very minute; and also bicalcarated bihamate, hami terminations truncated, numerous, very minute. Skeleton—rete very diffuse and open, primary lines with from three to five or six spicula in thickness; secondary lines irregular, mostly unispiculous, occasionally containing two or three spicula. Spicula acuate, stout and large. Internal defensive spicula attenuato-acuate, incipiently spinous, minute, few in number. Interstitial membranes spiculous; tension and retentive spicula same as those of the dermal membrane. Colour in the dried state light ochreous yellow. Habitat. Shetland, 170 fathoms (J. G. Jeffreys, Esq., and Rev. A. M. Norman). Examined in the dry state."

The type-specimen is fan-shaped, with several pliciform projections. It measures 7 inches in height and 10 inches across. The structure is so unusually open that the sponge is translucent in every part. It is a large and remarkably elegant species, on account of its open net-like structure. It was dredged 20–25 miles N. by W. of Burrafirth Lighthouse in 1867.

—— *fucorum* (Johnston). Abundant between tide-marks on the side of Halse Hellyer, Burrafirth.

—— *Barleei*, Bow. "Haaf Banks, Shetland, Mr. Barlee and Mr. Humphreys" (Bowerbank).

—— *fimbriata*, Bow. Abundant in one spot some 40 miles east of Whalsey Skerries, 1861, also to the north of Unst, 1868.

Genus Raphioderma, Bowerbank, n. g.

"Skeleton without fibres, composed of an irregular network of polyspiculous fagot-like bundles, the spicula of which are compactly cemented together at the middle, but are radiating at their terminations."

"*Raphioderma coacervata*, Bowerbank, n. sp. Sponge sessile, fan-shaped, thick. Surface even, irregularly areolated. Oscula simple, minute, numerous. Pores inconspicuous. Dermis reticulate; rete polyspiculous, irregular, very strong and wide. Dermal membrane pellucid, abundantly spiculous; tension-spicula attenuato-acerate, long and very slender, dispersed or loosely fasciculated; retentive spicula contort bihamate, minute and slender, exceedingly numerous, and dentato-palmate equianchorate, variable in size, few in number, dispersed or congregated in circular groups. Skeleton irregular and very coarse; rete polyspiculous; spicula subfusiformi-acerate, rather stout and long. Interstitial membrane spicula same as those of the dermal membrane; dentato-palmate, variable in size, equally dispersed, largest ones occasionally congregated in circular groups. Gemmules subspherical, membranous, aspiculous. Colour in the dried state cream-white. Habitat. Shetland, 170 fathoms, J. G. Jeffreys, Esq. and Rev. A. M. Norman." (Bowerbank, MS.)

Taken in company with *Isodictya laciniosa* in 170 fathoms, 20–25 miles N. by W. of Burrafirth Lighthouse, in 1867, and again in 1868. A very large and thick species, growing in flat lobate masses. The largest piece in my collection measures 11 inches long by $6\frac{1}{2}$ in its greatest breadth.

Genus OCEANAPIA*, Norman, n. g.

Sponge consisting of a hollow sphere filled with sarcode, surrounded by a hard spongeous crust of a very close and compact nature. From the opposite poles of the axis of the spherical or ovate body of the sponge there spring more or less numerous simple or branched fistulæ of great size and length; these fistulæ are also furnished at their base with prolongations, which, passing inwards into the central cavity of the sponge in the form of cylindrical branching tubes, are bathed in the great sarcodous mass. Skeleton spiculo-fibrous, irregularly reticulated; fibres polyspiculous, the primary lines, especially of the fistulæ, of great size. Spicula acerate, stout (Bowerbank, pl. i. fig. 2) and very minute, in the form of half a ring, "simple bihamate" (Bowerbank, pl. v. fig. 109). Dermal membrane reticulate; rete for the most part unispiculous; spicula of the same two kinds as those of the skeleton.

Oceanapia Jeffreysii (Bow.)=*Desmacidon Jeffreysii*, Bow. Brit. Spongiadæ, vol. ii. p. 347, =*Isodictya robusta*, ib. id. p. 304.

In 1861 I dredged a portion of the spherical crust of this sponge, from which the fistulæ had been abraded. This having been placed in Dr. Bowerbank's hands, was considered by him to belong to the genus *Isodictya*, and is described in his work under the name *I. robusta*. In subsequent expeditions to Shetland I obtained many detached fistulæ, and also portions of the crust, which convinced me that the entire sponge, when found, would prove to be something very different from what had been imagined by Dr. Bowerbank from the type specimen. In 1864 some of the fistulæ were forwarded by Mr. Peach to Dr. Bowerbank, who regarded them as a new species of *Desmacidon* (*D. Jeffreysii*). At length, during the past summer, several perfect specimens of the sponge have been dredged, and it is thus proved to be a remarkable species, perhaps the most interesting, as it is also one of the largest of British Porifera.

In form and size the adult sponge most strikingly reminds us of a full-grown swede turnip. Imagine such a turnip to be going to seed, and to have sent up several shoots. Now break these shoots off 4 or 5 inches from the bulb, strip off the leaves as well as the smaller fibrous portions of the roots, and scoop out all the interior of the turnip, leaving only the rind, and you will have a very fair idea of *Oceanapia*. The rind represents the spongeous crust; the hollow interior is a cup filled with sarcode; the broken off stems are the cloacæ, which are of about the size and shape of a finger, the smaller specimens having sometimes only one, but the larger as many as a dozen such cloacal fistulæ of various sizes, which are generally simple, more rarely branched. The roots of the turnip represent other fistular appendages of smaller size than those which spring from the crown, and of more solid and stringy texture. These appear literally to take the place of roots, since in one instance they grasp a pebble with their extremities, and in other cases

* *Oceanus* and *napus*, a turnip.

show evident signs of having been partially imbedded among sand. My largest specimen contained nearly a pint of sarcode in the interior. This sarcode is of deeper colour than usual among the sponges, and when the dried *Oceanapia* is cut open the sarcode will be found lying on that side which has been downwards when drying, shrunk into a solid deep brown or almost black mass, having somewhat the appearance and consistency of cobbler's wax.

Desmacidon fruticosus (Montagu). "Shetland, 1864" (Bowerbank in litt.).

—— *Peachii*, Bow. The type specimen. "Shetland, Mr. C. W. Peach" (Bowerbank).

—— *constrictus*, Bow. The type specimen. "Shetland, Mr. C. W. Peach" (Bowerbank).

Raphysus Griffithsiæ, Bow. "Shetland, Capt. Thomas and Mr. M'Andrew" (Bowerbank).

Diplodemia vesicula. "Shetland, Mr. Barlee" (Bowerbank).

Order KERATOSA.

Spongionella pulchella (Sowerby). "A young specimen coating part of a small bouldered granite pebble dredged by Mr. Jeffreys off the Outer Skerries, Shetland, in May 1864, from 50–80 fathoms depth" (Bowerbank).

Chalina oculata (Pallas). "Shetland, 1864" (Bowerbank in litt.). I have never myself seen this common species of our southern coasts in the extreme north.

—— *gracilenta*, Bow. "Shetland, 1864" (Bowerbank in litt.).

Verongia Zetlandica, Bow. Occasional, and widely distributed, but numerically scarce on the Outer and Middle Haaf.

Dysidea fragilis (Montagu). Rare, only two or three specimens observed.

POSTSCRIPT.

Since the Report on the Crustacea has been in print I have received the last part of Bate and Westwood's 'British Sessile-Eyed Crustacea,' which contains the appendix to that work. Among the species there described are several on which, as being connected with the present Report, it is necessary that I should say a few words.

"*Opis leptochela*, n. sp." This I find to be the species described by me under the name *Euonyx chelatus* (Brit. Assoc. Report, 1866 (1867), p. 202). My specimen differs from that described by B. & W. in having the second gnathopods larger and stronger than the first, and the hand furnished with a strong nail. This difference is perhaps one of sex. The species cannot, I think, be placed in the genus *Opis*.

"*Ampelisca lævigata*." Most unquestionably not the true *A. lævigata*, but the *A. tenuicornis* of Lilljeborg and of this Report. The characters given by B. & W. are the *exact reverse* of those which belong to the true *A. lævigata*.

"*Haploops tubicola*." B. & W. give "Shetland" on my authority, but I have never taken the species there. For "Shetland" read Hebrides*.

"*Lepidepecreum*." A new genus is characterized under this name to receive

* In the 'Zoological Record' for 1866, Mr. Bate, in referring to my Hebridean Report (Brit. Assoc. Report, 1866, p. 193), in every instance, by some *lapsus*, misquotes the habitat as "Shetland."

the *Anonyx longicornis*, which differs from *Anonyx* in having no secondary appendage to the upper antennæ.

"*Unciola leucopes*, Kröyer." B. & W. consider my *U. planipes* as "probably identical" with this species. It may be so, but there are points of difference which made me think it wiser to keep them apart until the examination of Greenland specimens should settle the question definitely.

"*Hyperia tauriformis*, n. sp." This is the *Metoëcus medusarum* of Kröyer and of this Report. B. & W.'s specimens were from Banff, forwarded by Mr. Edward, to whom I am also myself indebted for specimens.

In the 'Annals and Mag. Nat. Hist.' for January 1869, p. 49, pl. viii. figs. 13–15, will be found a description of *Cytherura flavescens*, by Mr. G. S. Brady; and in the 'Quart. Journ. Micros. Science,' January 1869, a full account by Prof. Allman of *Rhabdopleura Normani*.

Report on the Annelids dredged off the Shetland Islands by Mr. Gywn Jeffreys, 1867–68. *By* W. C. M'Intosh, *M.D., F.L.S.*

Mr. Gwyn Jeffreys, in his dredging-expedition to the Shetland Islands last year, kindly selected, chiefly with the assistance of Mr. Sturges Dodd and the Rev. A. M. Norman, a large number of Annelids, which he most courteously placed at my disposal; and, as they were properly preserved in vessels and fluid sent for the pupose, their subsequent examination proved very satisfactory. The same was done in 1868; but owing to the unfavourable state of the weather, the collection was very much smaller than that of the previous year.

The majority of the Annelids come from St. Magnus Bay, or, rather, from the deep water (80–100 fathoms) beyond this, not because they so disproportionately abound there (although the muddy sand is eminently favourable for their increase), but probably because the dredging was most frequently carried on in that neighbourhood. The other localities, in the order of the respective collections, are off Balta, North Unst, Bressay Sound, Outer Haaf (Skerries), Fetlar, and a small shore collection made by Mr. Dodd at Hillswick.

The Annelids found in the deep water off North Unst form a collection very rich in new or rare forms; for, out of thirteen species, three at least are new to science, and four not hitherto found in Britain. The collection from the Outer Haaf (Skerries) has also several rare forms; out of eight, four are new to Britain and one to science. Out of sixty found in St. Magnus Bay, four are new to science and eighteen to Britain. These figures contain the entire new or rare forms in the individual collections, without reference to their occurrence in others, as will be apparent when I mention that, out of a total of about ninety-two Annelids at present identified, five or six, so far as I can at present make out, are new to science, and about twenty-two to Britain. As before stated, this is one of the best collections of the kind ever made in Britain, whether in regard to the excellent condition of the preparations or the number of new forms. As might be expected, many of the additions to our fauna are Scandinavian in type; but others are not so, at least they do not occur in the valuable catalogue (Annulata Polychæta Spetsbergiæ, &c.) recently published by Dr. A. J. Malmgren, the enterprising naturalist of Helsingfors.

I have described some of the supposed new forms elsewhere, and therefore shall refer to them very briefly at present. They are as follows:—*Hipponoë Jeffreysii*, n. sp., a small Amphinomacean with a simple subulate antenna on the smooth elevation of the dorsum of the head. There is no caruncle. The branchiæ consist of tufts of simple processes, or they are bifid or somewhat fasciculated. The bristles of the superior lobe of the foot are for the most part shorter and stouter than the inferior, and of a characteristic shape. It is allied to the *Eurythoë borealis* of Sars. *Eunoa* ——, the second species of the genus found in Britain, the first being *E. nodosa*, Sars, also found in the Shetland seas by Mr. Jeffreys, and described by Mr. Lankester as a new form, under the name of *Antinoë zetlandica* (Linn. Trans. vol. xxv.); in the present species the scales are quite smooth, often bordered with a dark pigment-belt, and the inferior bristles of the feet have an entire clawed tip. *Sigalion Buskii*, n. sp., a form having the aspect of *S. boa* rather than that of *S. Mathildæ*, to which the scales are most nearly allied in structure; but the bristles are larger than in either case and characteristicallydifferent. *Notocirrus scoticus*, n. sp., a Lumbrinereian, with a dorsal branchial lobule to each foot, and found abundantly in comparatively shallow water in the Hebrides, where the bottom is clayey mud. *Eumenia Jeffreysii*, n. sp., a form first dredged by Mr. Jeffreys in the Hebrides, but too much decomposed to be minutely described: it is allied to *E. crassa*; but there are no traces of the branchial filaments in any specimen. A double row of isolated papillæ runs along each side from the snout to the tail, the summit of each giving exit to a bundle of forked and simple bristles. *Praxilla artica* (? Malmgren), a species that very probably is *P. artica* of that author; but as he has only mentioned that it is similar to *P. prætermissa* (differing in the hooks having six teeth), we are left quite in doubt as to his form. The teeth of the funnel are in general more filiform and distinct than in *P. prætermissa*. *Polycirrus* (?) *tribullata*, n. sp., a species having the snout and tentacles of a *Polycirrus*, but without the bristles or hooks in the anterior region, which is furnished with three circular and somewhat flattened papillæ on each side.

Of the forms new to Britain are—*Lætmonice filicornis*, Kinberg, which, however, is Dr. Baird's *L. Kinbergi*. *Harmothoë longisetis*, Grube, a widely distributed species, described by Mr. Lankester as *H. Malmgreni* (*op. cit.*), and therefore previouly found in Britain. *Panthalis Œrstedi*, Kinberg, a fine species with the habit of a *Sigalion*. *Sigalion limicola*, Ehlers, a form found by its discoverer in the Adriatic. It is rather abundant in the Shetland seas, but, so far as known, has not yet been found on any other part of the British coast. The anterior scales are furnished towards the outer margin with peculiar ragged processes. It has four eyes, and not two, as stated by Dr. Ehlers. *Nephthys ciliata*, Müller. *Genetyllis lutea*, Malmgren. *Anaïtis kosteriensis* (?), Malmgren. *Lumbrinereis fragilis*, Müller, a species which probably includes *L. tricolor* and some others, and therefore has been found previously on the British coast. It ranges from the Channel Islands to the north of the Shetlands, and large specimens occur at both extremities. *Onuphis sicula*, De Quatrefages, a curious species (inhabiting a tube composed of shell-fragments, stones, and sand), allied to *Hyalinœcia tubicola*, but differing entirely in the structure of certain of its bristles and hooks, and in the absence of the small brush-like bristles. It is not uncommon on the south coast of England, as well as in the Mediterranean. *Eone Nordmanni*, Malmgren, a species having the aspect of *Goniada maculata*, but differing amongst other particulars in the structure of the bristles of the dorsal lobe, which end in a somewhat blunt tip, furnished with a translucent conical apicial pro-

cess. *Scoloplos armiger*, Müller, a very common inhabitant of our western and northern sandy shores. *Naidonereis quadricuspidata* (Fabr.), Œrsted, also abundant in the same localities. *Trophonia glauca*, Malmgren, characterized by having bristles instead of hooks on the inferior division of the segments. *Chætopterus norvegicus*, Sars, a species which apparently comprehends *C. insignis*, Baird. *Scolecolepis cirrata*, Sars, not rare in the Shetland seas. *Rhodine Loveni*, Malmgren, which has its uncini placed in a double row as *Terebella*. It is one of the *Maldanidæ*. *Axiothea catenata*, Malmgren. This has an infundibuliform anal funnel with alternate longer and shorter filaments, and the base of the cup is marked exteriorly on the ventral surface by a continuation of the median line. The hooks have usually about six teeth on the summit above the great fang, though the anterior ones have fewer, and the posterior a larger number. *Praxilla prætermissa*, Malmgren, a form common on our western and northern shores, in a depth of 4 to 8 fathoms. *Praxilla gracilis*, Sars. *Clymene ebiensis*, Aud. & Ed., of which only a single incomplete example occurred. The hooks are less curved than in the foregoing species, and the crown somewhat flattened. The type was found on the coast of Brittany. *Ampharete artica*, Malmgren. *Sabellides sexcirrata*, Sars. *Grymæa Bairdi*, Malmgren, a species very closely allied to *Thelepus* (*Venusia*) *circinnatus*. *Lysilla Loveni*, Malmgren, which has six pairs of foot-papillæ in front, each with a submerged tuft of simple bristles. The dorsum is densely tuberculated, and the cephalic lobe furnished with clavate grooves and filiform tentacles. *Euchone analis*, Kröyer. *Chone infundibuliformis*, Kröyer.

The following is a list of the Zetlandic Annelids dredged in 1867 and 1868:—

Name of species.	Range.	Remarks.
	fathoms.	
Euphrosine foliosa, *Aud. & Ed.*	....	Hebridean seas.
Hipponoë Jeffreysii, n. sp.	100	St. Magnus Bay.
Aphrodita aculeata, *Linn.*	....	Only small specimens.
Lætmonice filicornis, *Kbg.*	90–100	Very abundant in the N. Hebridean and Zetlandic seas.
Lepidonotus squamatus, *Linn.*	0–60	
Nychia cirrosa, *Pallas*	....	
Eunoa ——, n. sp.	90	Found attached to *Spatangus purpureus* in one instance.
Harmothoë imbricata, *Linn.*	0–90	
—— longisetis, *Grube*	0–90	North Unst &c.
Lepidonotus pellucidus, *Ehlers*	80	Rare.
Polynoë scolopendrina, *Sav.*	0–15	Rare. It is abundant on the shores of the Hebrides between tide-marks.
Halosydna gelatinosa, *Sars*	0–8	
Panthalis Œrstedi, *Knbg.*	78	Rare. 35 miles off Out Skerries.
Sigalion boa, *Johnst.*	0	
—— Buskii, n. sp.	90–96	North Unst.
—— limicola, *Ehlers*	80–96	Very abundant.
Pholoë minuta, *Fabr.*	0–100	
Nephthys ciliata, *Müll.*	100	
—— cæca, *Fabr.*	0–50	
Genetyllis lutea, *Mgrn.*	100	St. Magnus Bay.
Anaïtis kosteriensis ?, *Mgrn.*	100	
Phyllodoce grœnlandica, *Œrst.*	100	
Eumida sanguinea, *Œrst.*	0–50	

Name of species.	Range.	Remarks.
	fathoms.	
Eulalia viridis, *Müll.*	0	
Eteone pusilla, *Œrst.*	100	
Ophiodromus vittatus, *Sars*	0–100	Most abundant in the Hebridean seas.
Castalia punctata, *Müll.*	0–100	
Syllis armillaris, *Müll.*	0–100	
—— artica, *Mgrn.*	100	
—— cornuta, *Rathke*	50	
Nereis pelagica, *Linn.*	0–100	
Hediste diversicolor, *Müll.*	0–100	
Nereilepas fucata, *Sav.*	100	
Heteronereis fucicola, *Œrst.*	....	
Lumbrinereis fragilis, *Müll.*	0–100	
Notocirrus scoticus, n. sp.	5–100	
Leodice norvegica, *Linn.*	50	25 miles N.N.E. of North Unst, Balta, &c.
Nothria conchylega, *Sars*	90–100	Abundant in the Hebridean seas.
Hyalinæcia tubicola, *Müll.*	50–100	
Onuphis sicula, *Quatref.*	90	Off North Unst.
Goniada maculata, *Œrst.*	80–100	
Eone Nordmanni, *Mgrn.*	90–96	St. Magnus Bay and N. Unst.
Glycera capitata, *Œrst.*	4–100	
Aricia Cuvieri, *Aud. & Ed.*	4–80	
Scoloplos armiger, *Müll.*	50	
Naidonereis quadricuspidata, *Œrst.*	70–80	
Ammotrypane aulogaster, *Rathke*	5–100	
Ophelia limacina, *Rathke*	50	
Eumenia Jeffreysii, n. sp.	50–100	
Scalibregma inflatum, *Rathke*	0–50	
Arenicola marina, *Linn.*	....	
Ephesia gracilis, *Rathke*	70	*Sphærodorum peripatus*, Johnst.
Trophonia plumosa, *Müll.*	6–8	
—— glauca, *Mgrn.*	70–100	
Chætopterus norvegicus, *Sars*	....	
Scolecolepis cirrata, *Sars*	80–100	
Cirratulus cirratus, *Müll.*	0–100	
Capitella capitata, *Fabr.*	50–90	
Rhodine Loveni, *Mgrn.*	40	Fragmentary. N. Hebridean seas.
Nichomache lumbricalis, *Fabr.*	0–100	
Axiothea catenata, *Mgrn.*	100	
Praxilla prætermissa, *Mgrn.*	70–80	
—— gracilis, *Sars*	100	
—— artica (? *Malmgren*)	70–90	
Clymene ebiensis, *Aud. & Ed.*	70–100	Fragmentary. Outer Haaf, Skerries.
Ammochares ottonis, *Grube*	4–100	Common.
Sabellaria alveolata, *Linn.*	....	Tubes only.
Pectinaria belgica, *Pallas*	50–100	
Amphictene auricoma, *Müll.*	100	
Ampharete artica, *Mgrn.*	80–100	
Amphicteis Gunneri, *Sars*	80–100	
Sabellides sexcirrata, *Sars*	80–100	
Terebella nebulosa, *Mont.*	0–5	
—— littoralis, *Mont.* ?	....	
—— figulus, *Dalyell*	....	
Nicolea zostericola, *Œrst.*	50	
Pista cristata, *Müll.*	70–80	Not uncommon.
Thelepus circinnatus, *Fabr.*	50–120	
Grymæa Bairdi, *Mgrn.*	70–80	
Polycirrus aurantiacus, *Grube*	70–80	

Name of species.	Range.	Remarks.
	fathoms.	
Polycirrus (?) tribullata, n. sp.	....	
Lysilla Loveni, *Mgrn.*	100	Fragmentary.
Trichobranchus glacialis, *Mgrn.*	100	
Terebellides Strœmii, *Sars*	5–100	Not uncommon.
Sabella pavonia, *Sav.*	....	
Euchone analis, *Kröyer*	80–100	
Chone infundibuliformis, *Kröyer*	80–100	
Protula protensa, *Grube et cæt.*	100	
Filigrana implexa, *Berkeley*	....	
Serpula vermicularis, *Linn.*	....	
—— reversa, *Mont.*	90	
Placostegus tridentatus, *Fabr.*	85	
Ditrypa arietina, *Müll.*	80–100	Abundant.
Tetrastemma variegatum	4–5	
Ommatoplea purpurea	6–8	
—— pulchra	....	
Lineus longissimus	0	
Meckelia annulata	....	
Cerebratulus tænia	....	
Entobdella hippoglossi	....	Parasitic on the Holibut.
Aulostoma gulo	....	Fresh water.
Clitellio arenarius	....	

Besides the foregoing, there are several whose examination, partly from their fragmentary state, has not been completed, and which are at any rate in the category of those new to Britain, viz. a *Sigalion*, a *Syllis*, an *Amage*, and a *Polycirrus*.

I may also remark, in passing, with reference to the other known forms in this collection, that the *Halosydna Jeffreysii*, Lankester (*op. cit.*), is *H. gelatinosa*, Sars, as mentioned in Dr. Günther's Zoological Record for 1866; and that I have not yet been able to make out a specific difference between *Leodice norvegica*, Linn., and *Eunice Harassii*, Aud. & Ed.

In addition to the foregoing, there was a very remarkable Nemertean allied to *Borlasia*, with a bifid proboscis, a complex structure of the muscular wall of the body; and a boring *Sipunculus*, lodged in its cavity inside a fragment of shell.

Report on the Shetland Foraminifera for 1868. *By* Edward Waller.

The almost unexampled stormy character of the summer in the Shetland Islands this year necessarily prevented dredging in the depths of 200 and more fathoms, which your Committee hoped to attain, and from which they reasonably expected additions to the British fauna in various departments.

The disappointment has, of course, affected the increase in the number of Foraminifera as of other orders. Notwithstanding this drawback, the examination of some of the fine siftings of our dredged stuff, even in a very cursory way, has brought to view some interesting forms hitherto unknown on our coasts. Amongst them a genus new to Britain, *Flabellina*, the observed species being very similar to the *Flabellina rugosa*, D'Orb., as found in the Lias of Somersetshire, and figured by Mr. H. B. Brady in the 'Proceedings

of the Somersetshire Archæological and Natural History Society,' vol. xiii. 1865–66. There are also some forms of *Lagena*, *Cristellaria*, *Uvigerina*, and *Bigenerina*, which seem sufficiently distinct from previously recorded British ones to be described under separate names; but I believe in no other order is there so much difficulty in defining the limits of species and varieties, and consequently so much danger of confusion in nomenclature. A more complete investigation of the dredgings will, I have no doubt, afford additional novelties.

In the list and remarks appended to my former Report (1867), I endeavoured to give as complete a view of the Shetland Foraminifera as our present knowledge permitted, so that a comparison can be made of their relation to those of the whole kingdom and of some neighbouring countries.

Addenda to the Rev. A. M. Norman's *Report.*

Cidaris papillata, Leske. I find that by some accident I have omitted to notice this species in the enumeration of species. It appears to be absent to the east and north-east of Shetland, as during our dredging in those directions we never saw any trace of it, and the fishermen at the Out Skerries were unacquainted with it. The specimens which have been procured through fishermen have been all from the western coast; and we had the pleasure of dredging the Piper in some numbers, 25–35 miles N.N.W off Unst in 110–170 fathoms in company with *Spatangus meridionalis* and other rarities. They appear to be very sluggish in their movements, as though kept alive for some time in a large tub of water, they showed very little inclination to change their position; of course, however, they found themselves placed in very unusual and probably very uncongenial conditions.

Amphiura tenuispina, Ljungman, "Tillägg till kännedomen af Skandinaviens Ophiurider," Œfvers. af k. Vet.-Akad. Förh. 1863, p. 360, pl. xv. fig. 1 = *Amphipholis elegans* var. *tenuispina*, Ljungman, "Ophiuroidea Viventia huc usque cognita," Œfvers. af k. Vet.-Akad. Förh. 1866, p. 312. The specimens of "*Amphiura elegans*" recorded in the foregoing Report from "40 fathoms, St. Magnus Bay," belong to *A. tenuispina*, Ljungman. That author at first described this form as a species, but in his more recent memoir considers it to be a deep-water form of *A. elegans*. On the other hand I at first regarded it in the latter light, but now think it may be a distinct species. For its characters I must refer the reader to Ljungman's paper. I find specimens of this Ophiuridan among the Echinodermata procured in the 'Lightning' expedition, and sent to me for examination by Messrs. Carpenter and Thomson; and dredged lat. 59° 40′ N., long. 7° 20′ W., on a bottom of fine mud in 530 fathoms and a temperature of 47° Fahr.

Pocillipora interstincta, Fleming, Brit. Anim. p. 511; Johnston's British Zoophytes, p. 194. This coral, found by Dr. Hibbert in the Shetland sea, has been an obscure species of which we have been able to make out nothing hitherto. I have recently, however, seen specimens of a highly interesting coral procured by Messrs. Carpenter and Thomson in the 'Lightning' expedition off Cape Wrath, lat. 59° 5′ N., long. 7° 29′ W.,

in 189 fathoms, and also a fragment sent to me to examine by Mr. D. Robertson, who procured it from Faroe, which exactly correspond with Fleming's brief description; and as the specimens which I have seen are from the north and from the south of Shetland, there is every likelihood of its having been found at the intermediate locality. A description of the species will be given by me in the Report of the Invertebrata procured in the 'Lightning' expedition.

Report on the Chemical Nature of Cast Iron.—Part I. *Account of some Experiments made to obtain Iron free from Sulphur. By* A. Matthiessen, *F.R.S., and* S. Prus Szczepanowski.

Following out the plan indicated in the preliminary report presented to the Association in the year 1866, we have been endeavouring to prepare pure iron, but have encountered greater difficulties than we expected, owing to the great affinity which iron has for sulphur. Although we have not been able as yet to prepare iron absolutely free from sulphur, yet the results, as far as they have been obtained, may be of interest to the Association, and a brief account of them is given in the following pages.

In the endeavour to prepare pure iron, we always found sulphuretted hydrogen on dissolving the metal in dilute hydrochloric acid. The small quantity of sulphur contained in the iron did not proceed from the hydrogen or from the platinum-tube in which the oxide was reduced. The manner of preparing the pure hydrogen and the precautions taken with the platinum-tube will be described hereafter.

The first series of experiments were made by precipitating the hot, concentrated, clear solution of protosulphate of iron by oxalate of ammonium, washing the precipitate till the wash-waters no longer indicated sulphuric acid with chloride of barium, heating the dried oxalate of iron to redness in a platinum-dish, and reducing the oxide thus obtained in a platinum-tube. The reduced iron contained sulphur. In all the experiments we describe sulphur was tested in the following manner. The iron was placed in a test-tube with some dilute pure hydrochloric acid, and the gases were allowed to pass through a small tube fitted into a cork in the test-tube, and to impinge on a paper moistened with acetate of lead. The evolution of sulphuretted hydrogen, after a very little experience, moreover is just as easily detected by the smell.

Experiments were also made with the oxalate of iron by redissolving it in hydrochloric acid and reprecipitating with ammonia, or by dissolving the oxide obtained by heating the oxalate of iron in hydrochloric acid, and reprecipitating again by oxalate of ammonium. In all these cases the reduced iron contained sulphur.

The second series of experiments were with iron obtained from the crystalline oxide. It is well known that when protosulphate of iron is fused with chloride of sodium, a crystalline oxide is obtained. For our experiments it was of course necessary to perform this operation in a platinum crucible, but it was found that the iron thus obtained contained a small quantity of platinum. We therefore employed instead of chloride of sodium the sulphate of sodium, and obtained an oxide which, after being thoroughly washed and reduced, gave an iron containing no platinum but still traces of sulphur. Experiments were then made by dissolving the crystalline oxide in pure

hydrochloric acid, and precipitating the solution by ammonia, washing the oxide, and reducing it. The iron thus prepared contained sulphur. The next experiments were made by dissolving the crystalline oxide in hydrochloric acid, digesting with chloride of barium for several days, decanting and filtering through paper (previously digested with dilute nitric acid), precipitating by ammonia (distilled from ammonia to which chloride of barium had been added), washing, and reducing the oxide. The iron thus prepared still contained sulphur.

The third series of experiments were made with sublimed proto- or sesquichloride of iron by dissolving it in water, precipitating with pure ammonia, washing, and reducing in hydrogen. All the specimens thus prepared contained sulphur. The sublimed chloride was obtained sometimes from the red oxide prepared by heating the oxalate of iron, obtained as above described, or from the crystalline oxide by dissolving it in hydrochloric acid, digesting with chloride of barium, evaporating to dryness, and subliming either in platinum vessels or in porcelain tubes, or in clay retorts, either alone or in a current of chlorine or of hydrochloric-acid gas.

In the fourth series of experiments the metal produced by either of the above methods was submitted in the platinum-tube, whilst red-hot, alternatively to the influence of hydrogen and oxygen, or hydrogen and steam, or of vapours of nitric acid and hydrogen, or of ammonia vapours, oxygen, and hydrogen. In all the cases the operation was repeated several times, and although sulphuretted hydrogen was given off during these operations, yet the iron always contained sulphur.

Further experiments were made by dissolving the purest iron in dilute acetic acid, evaporating to dryness and heating. The metal obtained still contained sulphur.

Also the iron obtained from ferrocyanide of potassium* was found to contain sulphur.

In fact we have never made or found a specimen of iron which did not contain sulphur. Even electrotype iron, said to be prepared from chloride of iron, evolved, by dissolving in dilute hydrochloric acid, a very appreciable quantity of sulphuretted hydrogen.

On the whole we have made upwards of seventy series of experiments.

From the above it will be seen that we have not yet obtained a method of preparing iron free from sulphur. In fact one great difficulty is to obtain vessels which will not give up sulphur to the iron in some form or another. For instance, the platinum-tube had to be polished and boiled out with acid every time before use. It may be mentioned that the hydrogen employed was led through the platinum-tube before reducing the oxide of iron for a quarter of an hour or more, and yielded no sulphuretted hydrogen.

Although no positive results have been obtained, we have in no ways lost hope of preparing iron free from sulphur. No doubt, on a very small scale, this might be done without much trouble; but we must bear in mind that our method must be such a one as to allow the preparation of pure iron on at least the ounce-scale.

November 1868.—The amount of sulphur contained in some specimens prepared since the Meeting of the Association amounted to only 0·001 to 0·005 per cent., the presence of the former quantity being easily detected both by the smell as well by the lead paper.

* Crystallized from a solution containing chloride of barium.

Interim Report of the Committee on the Safety of Merchant Ships and their Passengers.

As far as the Committee had been able to pursue their inquiry, it appeared that no legal regulations were in force in Great Britain affecting the loading of merchant ships; but there were regulations in force by the Board of Trade relating simply to vessels carrying passengers or emigrants, and these only related to space as bearing on the sanitary condition of such passengers, totally ignoring their safety as far as the stowage of cargo and deck-loads were concerned—the matter on which the Committee had to report. In order to carry out effectively any regulations, some precise agreement should be entered into with all the great maritime powers, and the deep draught of every vessel should be distinctly indicated by a fixed and clearly defined mark, such as a painted white ribbon extending about six feet on each side of the stem as well as stern-post (not in mid-ship), and so distinctly scribed in wooden and cut into iron ships that it could not be tampered with. When a ship was so loaded by the stern an average should not be taken, but when so loaded the load-line at that point should not be immersed. The load-line should be fixed by a government inspector. The great loss of steamers sailing from Hull had been occasioned by overloading and the shipping of successive heavy seas, the extra weight of which had caused the foundering of the vessels. Deck-loads might be carried during summer if well secured, and boats when stowed should be some height from the deck, so that the water shipped should have a clear passage. The lashings of the boats ought to be of rope, so that they could be readily cut in an emergency. Crews should be practised in the lowering of boats. The regulations thus indicated ought to apply to foreign vessels entering or leaving British ports.

Report on Observations of Luminous Meteors, 1867–68. *By a Committee, consisting of* JAMES GLAISHER, *F.R.S., of the Royal Observatory, Greenwich, President of the Royal Microscopical and Meteorological Societies,* ROBERT P. GREG, *F.G.S.,* E. W. BRAYLEY, *F.R.S.,* ALEXANDER S. HERSCHEL, *F.R.A.S., and* CHARLES BROOKE, *F.R.S., Secretary to the Meteorological Society.*

IN the first Appendix of this Report, immediately following the Catalogue, will be found the remarks of observers on the appearance of the August meteoric shower in the current year, together with the heights of eleven shooting-stars, simultaneously observed at English stations, on the occasion of its return. In addition to these results, the heights of several meteors, simultaneously observed in recent years by Professor Heis and his assistants, are contained in the first Appendix.

Large meteors, star-showers, and aërolites have continued during the past year to attract the attention of observers, especially on the 1st, 28th, and 31st of January, and on the 29th of February last. Brief accounts of their appearance, with other observations of luminous meteors, chronologically arranged, are entered in the Catalogue; while fuller accounts of the details and attendant circumstances of the phenomena are included in the second Appendix of the Report. The same Appendix also contains a collection of accounts (chiefly extracted from foreign sources) of the August and November

star-showers in the year 1867, illustrating the brief duration and the limits of the geographical area of visibility of those showers.

The expected reappearance of the November meteoric shower in the year 1866 was such a rare occasion for careful observations that, in anticipation of its return at the appointed time, the calculations of astronomers had previously been directed to determining the real velocities and orbits of shower-meteors. Of these bodies, the inquiries relating to the August meteor-ring led Mr. Schiaparelli to the remarkable discovery (which was shortly also verified in the case of the November meteors, at their reappearance) that the orbits of those meteor-groups coincide almost perfectly with the orbits of certain periodical comets. Some other investigations, of which recapitulations, owing to the number of observations of the November meteors contained in the Catalogue of the last Report, were deferred by the Committee until a more convenient opportunity should present itself for abstracting them, are contained in the last Appendix of this Report.

The entire series of charts of radiant-points, of four of which lithographed copies were last year exhibited to the British Association at Dundee, were afterwards printed, and bound together in an Atlas for distribution to observers, and to scientific persons and societies, of whose names and addresses a list is given in the same Appendix; and they were forwarded to their destinations at the close of last year. A new edition of the Meteor Atlas has since been prepared, with three new charts, and with the addition of several observations and improvements not contained in the previous Atlas. To indicate the characters and positions of all the radiant-points at present ascertained to exist in the northern hemisphere, a list of the meteoric showers which it portrays accompanies the Atlas, and is inserted in the last Appendix of this Report. Some copies of the new edition having now been printed, to assist in multiplying them, the Committee contemplate offering the whole of these copies for sale to observers at the lithographer's price.

The direction of shooting-stars in the southern hemisphere has, during the past year, been made the subject of a Memoir by Professor Heis and Dr. Neumayer. A series of nearly 2000 observations, obtained by the latter observer at Melbourne during the years from 1858 to 1863, having been submitted to examination by Dr. Heis, with a view to determining their points of radiation, thirty-nine radiant-points of shower-meteors were indicated by these researches in the southern hemisphere. Four radiant-points of Dr. Heis's list, which is given in connexion with the foregoing list in this Report, appear to be identical with four of the seventy-seven radiant-points observed in the northern hemisphere, leaving seventy-three separate radiant-points of meteoric showers recorded in the latter hemisphere alone. The general survey of meteor-showers, which at present extends to both hemispheres, accordingly increases the total number of radiant-points now recognized as clearly distinguishable from each other to about one hundred and twelve, or double of the number formerly reckoned in the list, as previously stated in these Reports*. For the purpose of verifying and investigating the connexion which apparently exists between certain of the radiant-points, the long duration and apparent fixity of position of others, and the dates of their maximum displays, a collection of further observations, and their regular discussion with a view to circumscribe the laws of the appearances of meteoric showers, will continue, on account of their increasing astronomical interest, to present an important subject of inquiry.

* For the year 1864, p. 99.

A CATALOGUE OF OBSERVATIONS

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1755. Aug. 15	h m About 7 30 p.m.	Leyden, Holland	Very large meteor (apparent diameter 4 inches).	Reddish nucleus, followed by a whitish tail.	Moderate speed.	Not globular b oval, with small tail, li an arrow fire. Detach from itself s veral brig particles on i course, whi burst, and so fell to t ground witho bursting.
1862. June 16	7 15 a.m. (local time).	Kingston, N. Adelaide, S. Australia.	Very large	....	....	Shot across the s
1866. Apr. 12	About 4 0 a.m.	Haverfordwest (Pembrokeshire, South Wales).	Large	....	....	....
June 27	10 58 p.m.	Hawkhurst (Kent).	=2nd mag.*	White	0·6 second ...	From 2° north u Honorum 2° north of Andromedæ.
July 15	11 14 p.m.	Ibid	=3rd mag.*	White	0·4 second ...	From α Dracor to η Ursæ M joris.
29	11 44 p.m.	Ibid	=1st mag.*.........	White	1·2 second ...	From $\frac{1}{2}$ (β, τ) $\frac{1}{2}$ (ζ, d) P gasi.
30	12 3 a.m.	Ibid	=1st mag.*	White	0·6 second ...	From 2 to d Cam lopardi.
Sept. 16	11 35 p.m.	Ibid	=2nd mag.*	Orange yellow	1·2 second ...	From $\frac{1}{2}$ (ϵ Pega γ Delphini) to Aquarii.
Oct. 18	1 15 a.m.	Ibid	=1st mag.*.........	Yellow	1·5 second ...	From e Lyncis e Ursæ M joris.
18	1 22 a.m.	Ibid	=1st mag.*	White	0·7 second ...	From β to ϵ Ur Majoris.
Nov. 6	7 0 p.m.	Stratford-on-Avon.	Very large	White	....	Appeared fi about 30° 35° altitude, S., and slop downwards, t wards, and the W.

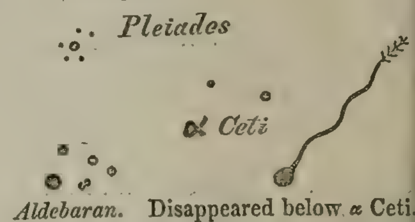
OF LUMINOUS METEORS.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
The brightest particles exploded with a noise like thunder, and were so observed to be detached from it in Flanders and in all the towns of Holland, where they were seen over a space of 40 leagues.	....	From N. to S., apparently parallel to the horizon.	The splendour was such as to cast a perfect shadow of terrestrial objects on the ground.	Letter of M. Muschenbroeck to M. de Réaumur. "History of the French Academy of Sciences" for the year 1756.
Like a large body of fire...	....	From E. to W.	Accompanied by a loud report, like that of a large cannon.	Dr. Neumayer's 'Report of Observations at Melbourne, 1862–67.'
Like a ball of white luminous matter. Burst like a rocket into a series of stars, and disappeared.	....	....	....	G. J. Symons's 'Monthly Meteorological Magazine,' May, 1866.
Brightest at middle of its course; left a streak for half a second.	....	....	....	A. S. Herschel
No train or sparks	....	Directed from χ Persei	Two meteors directed from this Radiant-point, in 45 minutes.	Id.
No train or sparks	....	....	....	Id.
No train or sparks	....	....	Two meteors in 30 minutes. Clear sky; moon $\frac{3}{4}$ full; one observer.	Id.
No train or sparks	....	....	Another, similar to it, almost immediately afterwards; from ϵ to θ Pegasi.	Id.
....	....	From Radiant O, in Orion.	....	Id.
....	....	From Radiant O, in Orion.	....	Id.
Rocket-like; burst in vanishing, leaving a large train.	....	....	....	Communicated by R. P. Greg.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1867.	h m					
Feb. 10	8 30 p.m. (local time).	France	Rather brighter than Sirius.	Bluish white...	....	Appeared at δ Geminorum; passed between α and β Canis Minoris, and disappeared between α and δ Canis Majoris.
22	11 0 p.m. (local time).	France	Large Bolide	....	....	At a small apparent altitude.
May 12	From 1 45 to 3 15 a.m. (local time).	Olivet, Mich., U. S. A.	Various	....	....	....
July 18	7 30 p.m. (local time).	Salem, Pennsylvania, U. S. A.	= ¼ moon	....	....	At about 40° elevation in the N.E. to S.E. quarter of the heavens.
Aug. 9	8 35 p.m. (local time).	Lyons, France ...	Half apparent diameter of moon.	....	....	From Cassiopeia to Polaris.
10	9 0 p.m. (local time).	France	Large meteor	Bright red ...	1 second	At altitude 30° above the horizon.
11	1 0 a.m. (local time).	Amboise, France	Large meteor	....	About 30 secs.	In the zenith ......
11	2 4 a.m. (local time).	Modena, Italy...	Larger and brighter than ♃.	....	....	From near C to near *k* Draconis.
20	About 10 0 p.m.	Edinburgh	Very large	Vivid blue ...	Slow motion...	Appeared to rise in the south, and travelled in a northerly direction nearly across the whole sky.
21	8 30 p.m. (local time).	Moncalieri, Turin, Piedmont.	Very large	Bright red ...	....	Appeared first just below Ursa Major, in the N.W., and disappeared in the S.E.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
The nucleus divided itself into seven parts, each part as bright as a 2nd mag. star.	....	....	....	'Année Scientifique,' of M. Figurier, for 1867, p. 38.
....	....	From S. to N.	Produced a flash like lightning; thirty or forty seconds afterwards a report like distant thunder was heard.	M. Bellanger; Ibid.
Twenty-eight shooting-stars.	....	[From precisely the W G Radiant.—R. P. Greg.]	"There seemed to be a tendency to radiate from a region north of Aquarius, between that constellation and Pegasus."	Prof. Hewitt and Mr. Gaines, Am. Journ. Sci., 2, xliv., 129.
Train 4° long	....	....	....	American Journ. of Science, 1867.
Left a bright white streak for 15 seconds.	....	....	....	M. Rias, 'Année Scientifique' for 1867, p. 42.
....	72°	From W. to E.	....	M. Negrier, Ibid. p. 43.
Consisted apparently of hundreds of smaller meteors moving together; left a streak of light for some time.	....	Moved in the direction from Amboise to Tours.	The light of the meteor was seen as far as Pocé.	M. Ducal, Ibid. p. 42.
Left a bright broad streak, which remained visible three minutes.	20°	Directed from the usual Radiant-point in Perseus [? from Pegasus].	Four drawings, and a description of the streak of this meteor accompany D. Ragona's Report on the August meteors in 1867 (see App. II.).	D. Ragona, 'Meteorologia Italiana,' Supplement, 1867.
A ball of fire, followed by a streaming fiery tail.	....	....	Lighted up the road with a sudden radiance. Midway, it paused, and seemed fading away, but immediately afterwards it resumed its course with increased brilliancy.	Edinburgh 'Courant.'
....	50°	....	The meteor *seemed to pass below the clouds*, in the S.E., which were not more than 1000 feet above the earth.	'Année Scientifique' for 1867, p. 43.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1867. Sept. 15	h m 11 4 p.m.	Clapham, London.	Very large	White in first one-third of its course; then red, with train of red sparks.	Motion remarkably equal and slow. Not more than 3 seconds while in sight.	Apparent path as in the annexed sketch.



Disappeared below α Ceti.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
30	6 40 p.m.	Ballater, Scotland.	One quarter of the apparent diameter of full moon.	White	Two or three seconds.	Appeared first near the square of Ursa Major.
Oct. 1	11 14 p.m.	Hawkhurst (Kent).	= 1st mag.*	White	1·8 second ...	From ϵ Cephei to σ Draconis.
2	12 22 a.m.	Ibid	= 1st mag.*	White	1 second	From θ to π Geminorum.
2	1 4 a.m.	Ibid	= 3rd mag.*	White	0·4 second ...	From θ, halfway to ϵ Aurigæ.
2	1 12 a.m.	Ibid	= 2nd mag.*	White	1·2 second ...	From l Draconis to β Ursæ Minoris.
15	About 5 30 p.m.	Ibid	'As large as a cricket-ball.'	....	Quick; about 1 second.	From about Polaris to near the head of Lynx. (Stars just beginning to be visible.)
15	About 5 30 p.m.	London	As bright as Jupiter (then visible).	....	....	A little north of due east.
18	10 55 p.m.	Hawkhurst (Kent).	= 2nd mag.*	Yellow	0·9 second ...	From ϕ to δ Ursæ Majoris.
18	11 5 p.m.	Ibid	= 2nd mag.*	Yellowish ...	1·2 second ...	From α Pegasi to ω Piscium.
18	11 10 p.m.	Ibid	= ♃	Orange yellow	0·8 second ...	First appeared at β Cygni.
18	11 30 p.m.	Ibid	= 3rd mag.*	Yellow	1 sec., slow...	From $\frac{1}{2}$ (c Muscæ ζ Arietis) to Pleiades.
18	11 34 p.m.	Ibid	= 3rd mag.*	Yellow	0·6 second ...	From τ Piscium to $\frac{2}{5}$ (α Andromedæ, α Pegasi).
18	11 44 p.m.	Ibid	= 3rd mag.*	White	0·5 second ...	From ν to ζ Andromedæ.
18	11 53 p.m.	Ibid	= 3rd mag.*	Yellow	0·8 second ...	From γ Ursæ Minoris, halfway to β Draconis.
19	10 54 p.m.	Ibid	= 1st mag.*	White	1·5 second ...	From η Cephei to η Lyræ.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Resembled the magnesium light, as seen in balloons on a night equally moon-light; disappeared without bursting; left a train on its course.	Half the distance between the moon and α Ceti.	Directed, in its apparent path, exactly from the moon. Course slightly undulating.	Beginning of the meteor's flight not seen. The moon's place too distant to be drawn in the same figure. So brilliant was the light as completely to overpower that of the full moon in a cloudless sky.	A. Finch.
Burst into several pieces. Left no streak.	About 30°...	Inclined thus— .... 	Seen in twilight; 1st mag. stars just visible; no report heard.	Communicated by A. S. Herschel.
Left no streak	....	....	....	A. S. Herschel.
Left no streak	....	....	....	Id.
Left a bright white streak for half a second.	....	....	....	Id.
Left no streak	....	....	....	Id.
Burst with sparks. Left no visible streak.	20°	Almost perpendicularly, thus— 	Seen by several persons standing near together, who called each other's attention to it; no report heard.	Communicated by A. S. Herschel.
Left a train	....	Fell almost perpendicularly.	Path not rectilinear ...	W. B. Davis.
Left a streak for 1 second	....	Directed from near ν Orionis.	....	A. S. Herschel.
Brightest at the middle of its course. Left no streak.	....	....	....	Id.
Left a broad yellow train for 5 seconds.	12°	Directed from α Cygni..	Brightest in the middle of its course.	Id.
Left no streak	....	....	....	Id.
....	....	....	....	Id.
No train or sparks	....	Directed from Cassiopeia.	Brightest in the middle of its course.	Id.
No streak left	....	....	Nine meteors in one hour; clear sky; moon half-full; one observer.	Id.
Left a streak for $1\frac{1}{2}$ second	....	Directed from ν Orionis	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1867.	h m					
Oct. 19	11 6 p.m.	Hawkhurst (Kent).	=1st mag.*	White	2 seconds; very slow motion.	From θ to κ Cygni
19	11 11 p.m.	Ibid	=3rd mag.*	White	1·4 second	From $\frac{1}{3}$ (u, λ) Honorum to f Lacertæ.
19	11 17 p.m.	Ibid	=2nd mag.*	White	0·5 second	Centre of path at β Cassiopeiæ.
19	11 24 p.m.	Ibid	=2nd mag.*	White	0·4 second	From μ to g Pegasi.
19	11 27 p.m.	Ibid	=3rd mag *	White	0·7 second	From γ to 61 Ceti.
19	11 35 p.m.	Ibid	=3rd mag.*	White	0·5 second	From m Custodis to π Cephei.
19	11 38 p.m.	Ibid	=2nd mag.*	White	0·6 second	Disappeared at ϵ Cygni.
19	11 43 p.m.	Ibid	=1st mag.*	Orange	0·8 second	From χ Piscium to q Pegasi.
19	11 45 p.m.	Ibid	=3rd mag.*	Yellow	0·5 second	Disappeared at $\frac{1}{2}$ (o, ξ) Persei.
19	11 55 p.m.	Ibid	=2nd mag.*	White	0·6 second	From c Muscæ to η Andromedæ.
20	12 8 a.m.	Ibid	=2nd mag.*	White	0·8 second	From τ Ursæ Majoris to κ Draconis.
20	12 15 a.m.	Ibid	=2nd mag.*	White	0·5 second	From ϵ Ursæ Minoris to ψ Draconis, and half as far further.
20	12 16 a.m.	Ibid	=1st mag.*	White	0·5 second	Centre of path 2° north of Pleiades.
20	12 24 a.m.	Ibid	=2nd mag.*	White	0·4 second	From b Lyncis to M Camelopardi.
20	12 27 a.m.	Ibid	=2nd mag.*	White	0·6 second	From μ Persei to $\frac{1}{3}$ (δ, ϵ Cassiopeiæ).
20	12 36 a.m.	Ibid	=1st mag.*	White	1·5 sec.; very slow speed.	In head of Aries
20	12 44 a.m.	Ibid	=1st mag.*	White	1 second	From N Camelopardi to γ Ursæ Minoris, and 8° further.
20	1 10 a.m.	Ibid	Brighter than 1st mag.*	White	0·8 second	From h Lacertæ to μ Cygni.
20	1 11 a.m.	Ibid	Brighter than 1st mag.*	White	1 second	From ϵ Cephei to α Cygni.
20	10 36 p.m.	Ibid	=2nd mag.*	White	1 second	From $\frac{1}{2}$ (θ, σ) Andromedæ to $\frac{1}{2}$ (η Pegasi, a Lacertæ).
20	10 41 p.m.	Ibid	=2nd mag.*	White	1 second	From η Piscium to q Pegasi.
20	10 43 p.m.	Ibid	=3rd mag.*	Yellow	0·2 second	From η Cygni to k Vulpeculæ.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Drew a train of red sparks 3° long; disappeared gradually; left no streak.	Very short course.	....	....	A. S. Herschel.
Left a streak for 1 second	....	Directed from feet of Gemini.	....	Id.
Left a streak for 1 second	12°	Directed from τ Tarandi	....	Id.
Left no streak	....	....	....	Id.
Left a streak for $1\frac{1}{2}$ second	....	Directed from ν Orionis	....	Id.
Left a streak for $\frac{1}{2}$ a second	....	Directed from feet of Gemini.	....	Id.
Left a streak for $\frac{1}{2}$ a second	Course $\frac{3}{4}$ from o Honorum.	Directed from o Honorum.	....	Id.
Left a broad pale streak for 2 seconds.	....	Directed from feet of Gemini.	....	Id.
....	8°...........	Directed from γ Geminorum.	Another, almost simultaneously with it, in the same path.	Id.
Left a streak for 2 seconds	....	From ν Orionis	Principal Radiant-space, on the nights of the 18th and 19th, a circle of 2° or 3° radius round ν Orionis.	Id.
Left a streak for $\frac{1}{2}$ a second	....	From ν Orionis	....	Id.
Left a streak for 2 seconds	....	From feet of Gemini ...	....	Id.
Left a bright streak for 2 seconds.	12°	Directed from β Tauri..	Brightest in the middle of its course; directed from feet of Gemini.	Id.
....	....	Directed from ν Orionis	....	Id.
Left a streak for 1 second	....	From ν Orionis	....	Id.
....	Very short course.	....	Almost stationary	Id.
Left a bright streak for 2 seconds.	....	From feet of Gemini ...	Another, from Orion, more to E., soon after it.	Id.
Left a bright streak for 3 seconds.	....	From feet of Gemini ...	Clear sky; half moon...	Id.
Left a broad streak for 3 seconds.	....	....	Three other small meteors, from Orion, in 15 seconds.	Id.
Left a streak for 2 seconds	....	From head of Orion ...	Three other small meteors, from Orion, about this time.	Id.
Left a streak for $2\frac{1}{2}$ seconds	....	From head of Orion ...	....	Id.
Left no streak	....	....	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1867. Oct. 20	h m 10 52 p.m.	Hawkhurst (Kent).	=3rd mag.*	White	0·6 second ...	From $\frac{1}{4}$ (ν, ξ) Ceti to ξ Piscium, and 4° further.
20	10 55 p.m.	Ibid	=2nd mag.*	White	1·2 second ...	From $\frac{1}{2}$ (o, p) Persei to $\frac{1}{2}$ (α Trianguli, α Arietis), and half as far further.
20	10 56 p.m.	Ibid	=1st mag.*	White	0·8 second ...	From $\frac{1}{2}$ (β, ϵ) to β Orionis.
20	10 57 p.m.	Ibid	=3rd mag.*	White	1 second	From δ Andromedæ to $\frac{1}{3}$ (μ, β) Pegasi.
20	11 3 p.m.	Ibid	=3rd mag.*	White	0·5 second ...	From C Camelopardi to $\frac{1}{3}$ (ϵ, ι) Cassiopeiæ, and 5° further.
20	11 7 p.m.	Ibid	Brighter than 1st mag.*	White	1·1 second ...	From $\frac{1}{4}$ (ξ_1 Ceti, p Piscium) to p Piscium.
20	11 11 p.m.	Ibid	=2nd mag.*	White	0·7 second ...	Commenced at C Draconis.
20	11 13 p.m.	Ibid	=2nd mag.*	White	0·8 second ...	From a Tarandi to β Cephei, and 4° further.
20	11 15 p.m.	Ibid	=3rd mag.*	White	0·6 second ...	From $\frac{1}{4}$ (ω Cephei, ω Draconis) to ω Draconis.
20	11 17 p.m.	Ibid	=2nd mag.*	White	0·7 second ...	From 29 Ursæ Majoris to $\frac{1}{2}$ (b, δ) Ursæ Minoris, and 4° further.
20	11 21 p.m.	Ibid	=3rd mag.*	White	0·6 second ...	From κ Cassiopeiæ to δ Cephei.
20	11 45 p.m.	Ibid	=1st mag.*	Yellowish white; train and sparks orange-red and yellow.	Slow speed; 1·2 second.	From 9 to b Lacertæ.
20	11 50 p.m.	Ibid	=1st mag.*	White	0·8 second ...	From g Psalterii to ζ Eridani.
29	About 9 30 p.m.	Glasgow, Scotland.	Half apparent diameter of the moon.	Yellow and red	Less than 1 sec.	At altitude about 45°, in the N.E.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Left a streak for 1½ second	....	Directed from ν Orionis	....	A. S. Herschel.
Left a streak for 2 seconds	....	From Auriga	....	Id.
Left a streak for 1½ second	....	From near ν Orionis ...	....	Id.
Left a streak for ½ a second	....	From ν Orionis	....	Id.
Left a streak for 1 second	....	From ν Orionis	....	Id.
Left a broad bright streak for 3½ seconds.	....	From near ν Orionis ...	....	Id.
Left a streak for 2 seconds	15°	Directed from ω Cephei	From Radiant in Orion	Id.
Left a streak for 2 seconds	....	From feet of Gemini ...	....	Id.
Left a streak for 1 second	....	From Orion	....	Id.
Left a streak for 1½ second	....	From Radiant L H_1, in Hydra.	....	Id.
Left a streak for 1 second	....	From belt of Orion ...	....	Id.
Began and ended small. A brilliant orange-yellow train and red sparks, 3° long, followed the nucleus, and remained visible half a second.	4°............	From Radiant, in Cassiopeia.	No other meteor seen in the last interval; moon rising; clear sky.	Id.
Left a streak for 2½ seconds	....	From ν Orionis	....	Id.
Nucleus elongated; front part bright yellow, followed by red streamers and sparks.	Short	Curved path, thus:— 	It appeared largest and brightest when turning, when it gave off numbers of red sparks.	G. Haley and W. Miller.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1867. Nov. 13	h m Between 10 45 p.m. and day-break on the 14th.	Cape of Good Hope, South Africa.	Bright meteors ...	Orange and green, &c.	....	....
14	Between 1 and 6 a.m. (local time).	Magnetic Observatory, Toronto, Canada.	Star-shower.........	....	....	....
14	Between 4 5 a.m. and 5 54 a.m. (local time).	Dudley Observatory, Albany, New York, U. S. A.	Star-shower.........	....	....	....
14	Between 1 10 a.m. and 5 30 a.m. (local time).	Newhaven, Connecticut, U. S. A.	Star-shower.........	....	....	....
14	Between 1 32 a.m. and 5 34 a.m. (local time).	Nassau, N. P., Bahamas, W. Indies.	Star-shower.........	....	....	....
15	Between 1 52 a.m. and 3 34 a.m. (local time).	Cape of Good Hope Observatory, South Africa.	Bright meteors ...	Orange and green, &c.	....	....
19	10 20 p.m.	Birmingham ...	=3rd mag.*	Blue	0·5 second ...	From α to γ Ursæ Minoris.
Dec. 22	5 55 p.m.	Ibid	=4th, 2nd, 4th, 1st mag. stars.	Dull blue, white, blue, white.	Slow speed; 2·5 seconds.	From π Andromedæ to ι Pegasi.
1868. Jan. 1	7 27 a.m.	Ropley (Hampshire).	About three times as bright as Jupiter appears at its brightest.	Pale straw colour.	5 seconds......	Disappeared at an altitude of about 30°, due east.
1	About 7 30 a.m.	Hawkhurst (Kent).	Large meteor	White	About 2 secs.	Nearly over the point of sunrise, a few degrees above the horizon. Centre of streak about 35° east from magnetic S.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Nine meteors observed ...	....	....	Bright moonlight, hazy in E.	G. W. H. Maclear, R.A.S., 'Monthly Notices,' vol. xxviii. p. 52.
2267 meteors seen in five hours.	....	....	Maximum number counted in 10 minutes by four observers, 430 meteors, between 4^h 10^m and 4^h 20^m a.m.	Americen Journ. of Science, Second Series, vol. xlv. p. 84.
1301 meteors observed in one hour and fifty-one minutes.	....	....	Maximum of frequency at 4^h 31^m a.m., viz. 47 in one minute: five observers, of whom two were continually on the watch.	Ibid. pp. 87–89.
About 5000 meteors observed in five hours.	....	....	Maximum frequency 43 meteors in one minute for one observer, at 4^h 35^m a.m.; strong moonlight; clear sky.	Ibid. pp. 78–82.
1040 meteors observed in one hour.	....	....	Maximum frequency 15 per minute for one observer, at 4^h 25^m a.m. Seen also at Trinidad, 1600 meteors, between 2^h a.m. and daybreak; and at Martinique.	R.A.S. 'Monthly Notices,' vol. xxviii. p. 54.
17 meteors observed	....	....	Bright moonlight; sky clear.	G. W. H. Maclear, Ibid. p. 53.
....	....	From Radiant A_{16}	Sky clear at 10^h p.m.; one meteor in 30 minutes; sky overcast on the nights of the 20th and 21st.	W. H. Wood.
Left no streak	....	....	Showed two minima and two maxima of size, with corresponding changes of colour and brilliancy.	Id.
Left a luminous streak, which remained visible twenty minutes. (See Appendix for its description.)	....	....	....	A. Harding, 'The Globe,' Jan. 3.
Disappeared gradually. Left a broad white streak like a bright silvery cloud.	....	....	Seen in twilight. The streak resembled a cloud lighted up by the rising sun.	Communicated by A. S. Herschel.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. Jan. 1	h m About 7 30 a.m.	Hurstpierpoint (Sussex).	Very large	....	....	Burst and disappeared at a point 10° above the horizon, 15° east from south.
1	About 7 30 a.m.	Woodford, Salisbury.	Large fireball	....	....	First appeared in the east; it then shot across towards the south.
1	About 7 30 a.m.	Shirley Warren, Southampton.	Size of a common rocket seen a quarter of a mile off.	White	Less than 30 seconds.	About 10° or 15° above the E.S.E to S.S.E. horizon. Centre of the path exactly over the spot where the sun was about to rise
1	About 7 30 a.m.	St. Helens, Isle of Wight.	Large meteor	Rainbow colours.	....	Began in S.S.E and ended in the south.
1	7 30 a.m.	Freshwater, Isle of Wight.	Apparent size of the full moon.	....	Moved rather slowly.	Passed from N.E to S.W., about 35° above the horizon, and disappeared in clouds, which were about 10 above the horizon.
1	Evening ...	Birmingham ...	....	....	....	....
1	10 25 p.m.	Hawkhurst (Kent).	=3rd mag.*	White	1·4 second ...	Commenced close to Castor.
1	11 29 p.m.	Ibid	=2nd mag.*	White	0·6 second ...	From κ Draconis $\frac{1}{2}$ (K, M) Camelopardi.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Like a Roman-candle-ball. Burst, and left two patches of vapour, forming a single horizontal streak of smoke, which floated eastward and persisted more than half an hour.	....	E. to W.; nearly horizontal.	Bearing of the point of disappearance (in the direction of Wolsonbury Hill) by Ordnance Map. Altitude by a trigonometrical observation. Probable error of the position not more than one degree.	A. R. Wallace, 'Daily Telegraph,' Jan. 2.
Burst like a rocket. Left a white streaming light, which remained in sight for full a quarter of an hour.	....	....	....	R. C. M., 'The Standard,' Jan. 3.
Rocket-like. Disappeared without bursting, and left a narrow light—tail behind it through the whole of its course. (See Appendix for description.)	....	....	....	F. L. Wollaston, 'Morning Advertiser,' Jan. 3.
Resembled a comet, leaving in its wake a bright stream of light, which remained visible for half an hour.	....	....	Produced a great light in the sky.	'The Standard,' Jan. 3.
The meteor did not burst before it disappeared, but left a broad trail of white light 60° in length; which was not yet overpowered by the sunlight at 8^h 5^m a.m.	....	....	From a broad straight line the streak assumed the form of a zigzag wave, composed of several parts, which appeared to the eye to be about three times as long as they were broad; no report heard.	H. M. W., 'The Times,' Jan. 2.
....	....	....	Overcast; night of the 2nd clear; an occasional watch kept, but no meteors seen.	W. H. Wood.
....	10°	Directed from γ Geminorum.	Two other small meteors at 10^h 40^m and 10^h 50^m p.m., in Orion and Canis Minor.	A. S. Herschel.
ucleus with sparks; left no streak.	....	....	Four meteors in 1 hour; sky $\frac{2}{3}$ clear; no moon; one observer. On the 2nd, sky clear till 9^h p.m.; no meteors seen.	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. Jan. 12	h m s 4 45 p.m.	Selkirk, Scotland	Large meteor	....	....	Ended its course exactly at the apparent place of Venus.
23	Evening (local time).	Sale, Victoria, S. Australia.	Large meteor	....	Several secs...	In the N. ....
23	About 8 0 p.m.	Glasgow	About equal to Venus at its brightest.	White	$2\frac{1}{2}$ seconds ...	In the S. ....
29	From 4 30 a.m. till daybreak.	Bergamo, Italy...	Various sizes	....	....	....
30	6 49 56 p.m. (D.M.T.)	Dantzig	Very large and bright meteor.	Green	2 seconds ...	From β Orionis (in the S.S.E.) to Sirius (8° above the horizon, 46° 8′ E. from S.).
30	About 7 p.m. (Breslau time).	Breslau	Half apparent diameter of the moon; well defined disk.	Bluish green...	1 sec. while in sight.	In the N.E. From κ Ursæ Majoris towards θ Leonis, disappearing 4° or 5° above the horizon.
30	About 6 45 p.m. (Breslau time).	Ibid	Apparent diameter of the full moon.	Red, tinged with yellow.	2 or 3 seconds; slow speed.	In the N.E., descending from a considerable height to the horizon.
30	Evening ...	Ragendorf, Hungary.	Large meteor; 2 or 3 × ♀.	Red; the train of many colours.	4 or 5 seconds	First appeared near α Draconis, and passed between ε, ζ Ursæ Majoris towards the horizon.
30	6 55 p.m. (O.M.T.)	Ofen	Half apparent diameter of the moon.	At first red, then greenish blue, then white.	5 or 6 seconds	From Corona, across β Ursæ Minoris, and between α and β Aurigæ towards the horizon.
Feb. 15	11 33 p.m.	London	= α Leonis	White	....	α= δ= From 135° + $16\frac{1}{2}$° to 120 + 1

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Burst with sparks at disappearance.	....	....	Another large meteor, seen at Ardrossan on an early Sunday evening in the same month, disappeared in the direction of Lochwinnoch (North Ayrshire).	W. Brown.
Left a luminous line in its wake; burst into innumerable brightly coloured particles at disappearance.	....	Described an arc of a segment of a circle.	....	'Melbourne Post.'
Disappeared, and then reappeared again, further on, almost like another meteor.	....	....	Clear sky	P. Innes.
Sixty meteors mapped in two hours, and seventy others counted before daybreak.	....	....	Pretty distinct Radiant-point, in Corona; at $\alpha=233°$, $\delta=+26°$ (G. V. S.).	M. Zezioli. Communicated by G. V. Schiaparelli.
Burst with a flash, scattering sparks in all directions. Left a momentary streak, which appeared to consist of sparks where the meteor burst.	....	W. to E.	The brilliancy of the meteor was very uniform throughout. [A shower of stones fell at Pultusk, see Appendix II.]	— Kayser. Note by J. G. Galle.
Dazzling at first; form undistinguishable; followed at last by a small red train. Disappeared without bursting.	....	Vertically down, from S.W. by W. to N.E. by E.	Passed behind a cloud, which it lighted up brilliantly from N. to E., and reappeared as a red fireball falling nearly to the horizon. (See Appendix II.).	— V. Sichart. Note by J. G. Galle.
Pear-shaped, round below, and ending in a point.	....	Quite vertically down...	Lighted up all objects with a dazzling light.	'Schlesische Zeitung,' Jan. 31.
At first a small shooting-star; it became a large fire between ϵ and ζ Ursæ, and proceeded thence to the horizon, scattering sparks on its course.	....	....	Illuminated the clouds near the horizon for one second with a light like red fire.	— Schuh. Note by J. G. Galle.
A large fireball	....	N. to S., passing overhead.	[*"Corona" not yet risen.* A different meteor from the preceding one.]	F. Schenk. Note by J. G. Galle.
Dull train, and streamers from the nucleus.	About 17°...	Inclined downwards to right.	A smaller meteor from same Radiant at 11^{h} 40^{m} p.m.	T. Crumplen.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. Feb. 16	h m About 9 30 p.m. (local time).	Annesley Bay, Red Sea.	? Large meteor ...	The light shown was greenish blue.	....	....
19	About 8 10 p.m.	Birmingham ...	=1st mag.*	Pale blue	....	From τ_2 towards α Hydræ.
19	10 52 p.m.	Ibid	=3rd mag.*	Ruddy	1 second	From γ Persei, halfway to γ Andromedæ.
20	Between 10 30 and 11 30 p.m.	Manchester	....	Dull red	Moderate speed.	From near α Ursæ Majoris to near α Cephei.
25	10 13 p.m.	Birmingham ...	=1st mag.*	Deep blue ...	0·5 second ...	From ζ to $\frac{1}{2}$ (β, γ) Leporis.
Mar. 14	9 20 p.m.	Ibid	=3rd mag.*	Blue	0·75 second ...	$\alpha=$ $\delta=$ From 54° +27° to 40 +24
15	About 10 15 p.m.	Camberwell, London.	Very bright shooting-star.	....	....	In the N. ....
28	7 40 p.m.	Cumbray (Scotland).	Half apparent diameter of the moon.	Yellow	1 second, very quick.	Disappeared near the horizon, close above the spot where the sun had just set.
29	9 13 p.m.	Birmingham ...	=1st mag.*	Blue	0·5 second ...	From α Leonis to $\alpha=$ $\delta=$ 154° + 8°
29	9 14 p.m.	Ibid	=3rd, then > 1st mag.*	Reddish yellow.	2 seconds......	From σ to omicron Leonis.
Apr. 10	Between 10 30 and 11 30 p.m.	Manchester	=$1\frac{1}{2}$ mag.*	White	Slow motion...	Centre of path near and below omicron Herculis.
10	Between 10 30 and 11 30 p.m.	Ibid	=3rd mag.*	Dull	Slow motion...	From η Boötis to o Canum Venaticorum.
11	Between 10 30 and 11 30 p.m.	Ibid	=$1\frac{1}{2}$ mag.*	White	Quick motion	From f Lyncis to θ Aurigæ.
11	Between 10 30 and 11 30 p.m.	Ibid	=$1\frac{1}{2}$ mag.*	White	Quick motion	From u Lyncis to f Geminorum.
12	Between 10 30 and 11 30 p.m.	Ibid	=3rd mag.*	Dull	....	Centre of path near μ Herculis.
12	Between 10 30 and 11 30 p.m.	Ibid	=2nd mag.*	White	Quick motion	From y Leonis Minoris to λ Leonis, and 3° further.
13	Between 10 30 and 11 30 p.m.	Ibid	=$1\frac{1}{2}$ mag.*	White	Slow motion...	Near α Herculis ...

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
It gradually lightened up, till everything around was shown nearly as clearly as if it were day, then it quickly faded.	....	....	The sky was cloudy and so overcast that nothing could be distinguished. There was a low rumbling sound at the same time like thunder.	J. P. Maclear.
....	....	From Radiant $M_{1, 5}$ ...	Intercepted view.........	W. H. Wood.
....	....	From Radiant M_3	Rate of appearance, one meteor in 30 minutes: clear sky. On the nights of the 20th, 21st, 22nd, and 23rd sky overcast.	Id.
Intermittent light; vanished once in its course. Left no train.	....	From Radiant ? B_3 or $S_{2, 3}$.	One meteor only in one hour; clear sky; one observer.	R. P. Greg.
Left a train	....	From Radiant $A_{3, 4}$......	....	W. H. Wood.
....	....	From Radiant S_4.........	....	Id.
Left a long streak of light	....	....	....	Communicated by T. Crumplen.
Globular; no sparks; disappeared gradually. Left no train.	....	From E. to W., inclining downwards, thus— 	Seen in bright twilight.	James Thomson. Communicated by A.S. Herschel.
Increased from a second to a first mag. star.	....	From Radiant $A_{3, 4}$......	....	W. H. Wood.
Left a smoky train on its path.	....	From Radiant S_4.........	No other meteors seen on this night.	Id.
....	2°............	Directed from α Lyræ...	From Radiant Q $II_{1, 2}$ ...	R. P. Greg.
....	....	From Radiant $M_{6, 7}$ ...	....	Id.
....	....	From Radiant $M_{7, 8}$......	....	Id.
....	....	From Radiant $M_{7, 8}$ ...	....	Id.
....	....	Directed from θ Lyræ; Radiant D G_2.	....	Id.
....	....	From Radiant $M_{7, 8}$ ...	....	Id.
....	2°............	Directed from α Lyræ...	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868.	h m					
Apr. 13	Between 10 30 and 11 30 p.m.	Manchester	=3rd mag.*	Dull	Moderate speed.	Near κ Cygni ......
13	Between 10 30 and 11 30 p.m.	Ibid	=3rd mag.*	Dull	Moderate speed.	Close to η Herculis
13	Between 10 30 and 11 30 p.m.	Ibid	=3rd mag.*	Dull	Slow motion...	Centre of path near γ Cygni.
23	Between 10 30 and 11 30 p.m.	Cheshire	=3rd mag.*	Dull	1 second	From α to κ Serpentis.
24	Between 10 30 and 11 30 p.m.	Ibid	=1st mag.*.........	White	2 or 3 seconds	From η to near ι, κ Ursæ Majoris.
24	Between 10 30 and 11 30 p.m.	Ibid	=3rd mag.*	Dull	0·5 second ...	From κ Cephei, $\frac{3}{4}$ of the way to P Camelopardi.
24	Between 10 30 and 11 30 p.m.	Ibid	=3rd mag.*	Dull	0·5 second ...	Close to ϵ Virginis..
25	10 41 p.m.	Birmingham ...	=3rd mag.*	Blue	0·3 second ...	From ι to δ Ophiuchi
25	11 5 p.m.	Ibid	=1st mag.*	Bluish white...	0·5 second ...	From α, $\frac{2}{3}$ of the way to η Draconis.
26	9 45 p.m.	Ibid	=2nd mag.*	Blue	0·5 second ...	From ζ Coronæ to ϵ Boötis.
27	About 8 30 p.m.	Cheshire	Quarter apparent diameter of moon.	Bright red, then white.	3 seconds ...	Near the constellation Libra, about 8° above the S.S.E. horizon.
28	Between 10 30 and 11 30 p.m.	Ibid	=$1\frac{1}{2}$ mag.*	Yellowish white.	3 seconds ...	From near α Boötis to λ Herculis.
28	Between 10 30 and 11 30 p.m.	Ibid	=1st mag.*.........	Reddish white	1·5 second ...	Centre close to ϵ Virginis
29	10 35 p.m.	Birmingham ...	=2nd mag.*	White	0·5 second ...	$\alpha=$ $\delta=$ From 216°+21° to 200 +46
May 10	9 58 p.m.	London	=$2\frac{1}{2}$ mag.*	White	....	From 10° below η Ursæ Majoris to w Virginis.
10	10 22 p.m.	Ibid	=2nd mag.*	White	....	From κ Lyræ to 3° below δ Herculis.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
....	2°............	Directed from Radiant Q_1 in Corona.	....	R. P. Greg.
....	4°............	Directed from α Coronæ; Radiant Q_1 ?.	....	Id.
....	8°............	Directed from head of Draco; Radiant D G_2.	....	Id.
....	....	Directed from β Libra; from Radiant S G_2.	....	Id.
Left a momentary train ...	....	Directed from Corona...	Radiant Q_1 or A_1	Id.
....	6°............	....	....	Id.
....	2°, nearly stationary.	Directed from Comæ Berenices.	Close to the Radiant $S_{5,6}$.	Id.
Left no train	....	From Radiant Q H_2, near α Lyræ.	....	W. H. Wood.
Left no train	....	From Radiant $M_{6,7}$......	....	Id.
Left no train	....	From Radiant D G_2 ...	Four telescopic meteors in one hour. Sky clear. From 10^h to 11^h p.m., no meteor visible. Fine auroral arch on the 27th.	Id.
It appeared at first nearly stationary, expanding from a star of the second magnitude, and then suddenly vanished.	2° or 3° ...	From Radiant (?) S G_2...	Appeared close to this Radiant-point.	R. P. Greg.
Left a slight train	....	....	....	Id.
Expanded like a small rocket, and burst at disappearance.	Nearly stationary.	From Radiant $S_{5,6}$ ...	Appeared very much foreshortened, and close to the Radiant-point.	Id.
....	....	From Radiant S G_2 ...	One meteor seen in 45 minutes. Sky overcast at $10^h\ 45^m$ p.m.	W. H. Wood.
....	....	Downwards towards S.W.; directed from η Ursæ Majoris.	....	T. Crumplen.
Left a long filmy streak...	....	Downwards to right ...	Another small meteor from α Lyræ within three minutes of this.	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. May 11	h m s 10 23 p.m.	London	=1st mag.*	Pale blue......	$\frac{1}{2}$ second	From η Ursæ Majoris to $1\frac{1}{2}°$ beyond and above τ, υ, ϕ Herculis.
12	10 24 p.m.	Ibid	=1st mag.*	Pale blue	....	$\alpha=$ $\delta=$ From 217°+52° to 233 +23
12	10 29 p.m.	Ibid	Nearly = α Lyræ ...	Same colour as α Lyræ.	....	From 200°+40° to $186\frac{1}{3}$+28
12	10 41 p.m.	Ibid	Nearly = α Lyræ ...	Pale blue	....	From 268°+$28\frac{1}{2}$° to 260 +$20\frac{1}{2}$
13	9 57 p.m.	Ibid	=3rd mag.*	....	....	From near η Ursæ Majoris; shot through Comæ Berenices.
14	10 0 p.m.	Birmingham ...	= ♃	White	2·5 seconds ...	From θ Virginis to $\frac{1}{2}$ (β Virginis, θ Crateris).
17	Evening ...	Manchester	Several bright shooting-stars.	White	Quick motion	Between β Libræ and Corona; near α Serpentis.
18	9 54 p.m.	London	= ♄	Ruddy	2 secs.; moved slowly and leisurely.	Disappeared 5° above the E.S.E. horizon, commencing 12° W. of the same point.
18	10 28 30 p.m.	Ibid	= α Coronæ.........	Pale blue ...	Much swifter than the preceding meteor.	From near θ Herculis to $\frac{1}{2}$ (A Herculis, γ Lyræ), and a few degrees further.
19	9 55 p.m.	Ibid	=$2\frac{1}{2}$ mag.*	White	....	Began 15°, and ended 8° above η Ursæ Majoris.
19	9 59 30 p.m.	Ibid	= Arcturus	White	....	Disappeared between β and γ Ursæ Minoris.
19	11 0 p.m.	Hawkhurst (Kent).	=2nd mag.*	White	0·2 second ...	From $\frac{1}{2}$ (ι, κ) Cygni, halfway to π Lyræ.
19	11 18 p.m.	Birmingham ...	=2nd mag.*	Bluish white...	1 second	From ξ Herculis to δ Cygni.
19	11 20 p.m.	Ibid	=3rd mag.*	Dark colour...	0·75 second ...	From B Herculis to κ Ophiuchi.
20	12 2 a.m.	Ibid	=1st mag.*, then =3rd mag.*	White, then red.	2 seconds ...	Disappeared at α Equulei.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Left a very luminous broad train, tapering at the ends.	12°	Downwards to left......	Two maxima of brightness. Appeared to go out in the middle of its course.	T. Crumplen.
Left a very bright, long, tapering train.	....	Downwards to left......	....	Id.
....	....	Downwards to right ...	Another small meteor at 10^h 31^m p.m., with long flight downwards to E.S.E.; apparently from α Lyræ.	Id.
Left a train on its whole course.	....	....	A small meteor from α Lyræ, whilst recording this.	Id.
....	....	....	No other shooting-star in 20 minutes.	Id.
Increased from a second magnitude star to the brightness of Jupiter, became pear-shaped; anterior crescent silvery white fringed with blue.	....	From Radiant S Z_1	Left a smoky streak 15° long for ½ a second. No other meteor in one hour. Night of the 13th overcast.	W. H. Wood.
....	Short paths	From an apparently new Radiant-point near α Serpentis, viz. S Z_2.	Similar shooting-stars to these were observed at about the same time last year.	R. P. Greg.
Globular; left a slight train.	....	Directed from near γ Virginis.	....	T. Crumplen.
Left a bright train on its whole course.	9°	From a Radiant near η Ursæ Majoris.	No meteors seen in the south between 9^h 54^m and 10^h 28^m 30^s p.m.	Id.
....	7°...........	Perpendicularly down...	Six shooting-stars seen between 9^h 50^m and 10^h 30^m p.m.; afterwards overcast.	Id.
Left a very luminous train 7° or 8° long.	20°	From right to left	Moved along a line drawn from α Coronæ.	Id.
....	....	....	....	A. S. Herschel.
No train or sparks	....	From Radiant S G_2 ...	....	W. H. Wood.
....	....	From Radiant W........	....	Id.
At first white; globular; diminishing soon after the middle of its course to a dull red spark.	10°	Directed from η Lyræ...	....	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. May 20	h m s 12 25 a.m.	Birmingham ...	=3rd mag.*	White	1 second	Centre of path at μ Lyræ.
20	12 33 a.m.	Ibid	=1st mag.*	Bright white...	1·5 second ...	From e Cephei to ½ (o Cassiopeiæ, κ Andromedæ).
20	12 33 30 a.m.	Ibid	=1st mag.*.........	White	1 second	From b Draconis to 33 Cygni.
20	12 35 a.m.	Ibid	=2nd mag.*	White	0·8 second ...	From ½ (α, δ) to ½ (δ, ϵ) Ursæ Minoris.
20	12 45 a.m.	Ibid	=3rd mag.*	White	2·5 seconds ...	From ½ (β Cygni, δ Sagittæ) to s Vulpeculæ, and 3° further.
20	1 6 a.m.	Ibid	=1st mag.*	White	1 second	Commenced at θ Ophiuchi.
20	1 47 a.m.	Ibid	=2nd mag.*	White	0·8 sec.; rapid	From α Capricorni to ϵ Aquarii.
20	10 45 p.m.	Ibid	=2nd mag.*	Bluish white...	Slow speed; 1 second.	From σ Coronæ to $\alpha=260°$ $\delta=+40°$
20	11 20 p.m.	Ibid	= Sirius	White	Rapid; 0·3 sec.	From $\alpha=106°$ $\delta=+70°$ to 111 +55
25 (or?26)	10 13 p.m.	Witham (Essex)	Large meteor	....	2 seconds......	From Comæ Berenices to λ Hydræ.
25	10 35 p.m.	Birmingham ...	Much larger and brighter than Venus.	White as Vega Lyræ.	....	From right arm of Hercules, across Aquila.
27	Between 10 55 and 11 20 p.m.	Manchester	=2nd mag.*	Dull, misty ...	Very rapid ...	From η Ursæ Majoris to θ Leonis.
27	Between 10 55 and 11 20 p.m.	Ibid	=3rd mag.*	Dull, misty ...	Very rapid ...	From α Canum Venaticorum to β Leonis.
27	Between 10 55 and 11 20 p.m.	Ibid	=2nd mag.*	White	Quick motion	Centre of path at η Herculis.
27	Between 10 55 and 11 20 p.m.	Ibid	=1st mag.*	Very white ...	....	From H Draconis to β Cephei.
27	11 5 p.m.	Hawkhurst (Kent).	=3rd mag.*	White	0·6 second ...	From θ Herculis to κ Lyræ.
27	11 15 p.m.	Ibid	=2nd mag.*	White	0·6 second ...	From A Herculis, ¾ way to ½ (α Herculis, α Ophiuchi).
28	12 14 a.m.	Ibid	=2nd mag.*	White	0·6 second ...	From ψ Draconis to δ Ursæ Minoris.
28	12 17 a.m.	Ibid	=3rd mag.*	White	0·5 second ...	One flash at α Delphini; the other at α Capricorni.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
....	10°	Directed from γ Draconis.	....	W. H. Wood.
Brightest at first; faded gradually till it disappeared.	....	....	Curved in last part of its course.	Id.
....	....	....	....	Id.
Brightest at middle of its course.	....	....	....	Id.
Grew brighter, and then faded gradually.	....	....	....	Id.
Brightest at the middle of its course.	8°...........	Directed from o Tauri Poniatovii.	....	Id.
Left no streak. Brightest at the middle of its course.	....	....	None of the meteors seen on this night left streaks. The larger ones bright white. One changed to red at last.	Id.
....	....	From Radiant Q_2.........	....	Id.
....	....	....	Ten meteors in 45 minutes. Fine clear sky.	Id.
Appeared descending, like an inverted rocket.	....	....	....	W. B., 'The Times,' May 28.
Egg-shaped. No train or sparks.	....	....	A splendid meteor. Beginning and end of its path not seen. Strong moonlight.	W. H. Wood.
....	....	From Radiant D G_2 ...	....	R. P. Greg.
....	....	From Radiant D G_2 ...	....	Id.
....	6°	Directed from α Lyræ. From Radiant W.	....	Id.
Gave off sparks and burst	....	From Radiant S G_2 or S Z_2 in Serpens.	....	Id.
....	....	....	....	A. S. Herschel.
....	....	....	....	Id.
Brightest at the middle of its path.	....	....	....	Id.
Two stationary flashes ...	....	....	Almost simultaneous ...	Id.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. May 28	h m s 12 39 a.m.	Hawkhurst (Kent).	=2nd mag.*	White, then red.	3·5 secs.; slow speed.	From ζ Coronæ to Q Cephei.
June 5	10 11 p.m.	Birmingham ...	=3rd, then =1st mag.*	Dull yellow ...	2 seconds; slow.	α= δ= From 197°+18° to Arcturus.
8	9 50 p.m.	Radcliffe Observatory, Oxford.	Large meteor (?); 5° in length, and 1° in breadth.	White	Nearly *four minutes.*	First situated a little west of Polaris. Thence passed just below α, β Ursæ Majoris, on a course directly west, to near the N.W. horizon.
13	9 15 p.m.	Hawkhurst (Kent).	Brighter than Venus appears at its brightest.	White	5 or 6 seconds (observer counted slowly up to 27).	From altitude 25° due S., to altitude 20°, S.E by S. (Positions measured from bearings, on the spot.)
18	11 59 p.m.	Manchester	=1st mag.*.........	White	2·5 seconds ...	From near Lacertæ to η Draconis.
19	12 1 a.m.	Ibid	=1st mag.*.........	White	0·75 second ...	Close to η Ursæ Majoris.
19	12 9 a.m.	Ibid	=1½ mag.*	Bluish white...	1 second	Close to β Andromedæ.
19	12 20 a.m.	Ibid	=1st mag.*	White	0·5 second ...	Above the N.W horizon, near Comæ Berenices
19 (or ? 26)	About 10 p.m.	Hastings (Sussex).	As large, but not so bright as Venus.	Dull orange yellow.	Moved quite slowly.	In the N.E., at an altitude of about 25°.
19	11 50 p.m.	Manchester ...	=1st mag.*.........	White	0·75 second ...	From τ Cygni to λ Cephei.
26	10 43 p.m.	Hawkhurst (Kent).	=2nd mag.*	White	About 1 sec...	From ο Cygni to ρ Cephei.
26	11 15 p.m.	Ibid	=2nd mag.*	White	About 1 sec...	Centre at ½ (ε Ursæ Minoris, γ Persei).
26	11 15 30 p.m.	Ibid	=2nd mag.*	White	½ second	From H to C Camelopardi.
July 19	10 15 p.m.	Birmingham ...	=3rd, then = 1st mag.*	Dull yellow ...	2 seconds......	From δ Ursæ Majoris to α=200°, δ=+44°.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Bright white in the first $\frac{1}{3}$ of its course; then red, drawing a tail of red sparks.	....	Course slightly undulating.	Rate of appearance seven meteors per hour. Moon set at $11^h 30^m$. Clear sky; one observer.	A. S. Herschel.
....	....	From Radiant Y_2, in Leo	Full moon. Night of the 20th clear; no meteors: of the 21st overcast; of the 22nd fine; no meteors. The month fine, but barren in meteors.	W. H. Wood.
white cloud; like a comet, or the smoke of a railway train faintly illuminated by twilight. On starting into motion, it left on its whole course a train broader than itself, which remained visible after the meteor had disappeared.	....	When near Leo, it turned somewhat southwards, to near Regulus; and then northwards again.	A thick haze all the night, and mock-moon at $13^h 40^m$. Another meteor, on the 24th of June, was recorded by Mr. Allnatt, at Frant, in Sussex.	'The Times,' June 15 and July 2: communicated by W. H. Wood and R. Main.
ew a slight train of smoke behind it at last, and disappeared without bursting.	....	Nearly horizontally from W. to E.	No stars yet visible in the twilight. First seen reflected in still water, and directly afterwards skirting the tops of some trees. The observer counted twenty-seven while it was in sight.	T. Humphreys. Communicated by A. S. Herschel.
osphorescent train;? without a nucleus.	20°	....	....	R. P. Greg.
t a momentary train ...	2°	Directed from Lyra. Radiant W?.	....	Id.
t a train	4°	Directed from Ursa Minor.	From Radiant $N_{9, 10}$, or B_1?.	Id.
....	2°	Perpendicularly down; directed from Ursa Major.	From Radiant M G_3? ...	Id.
bular. Disappeared ithout bursting; left o train or sparks.	20° or 30°	From E. to W.; nearly horizontal.	The last, or one before the last. Friday evening in June.	Communicated by A. S. Herschel.
a train	6°	From Radiant M G_3 ...	No meteors from Radiant $Q_{1, 2}$, in Corona, seen in four evenings.	R. P. Greg.
llar; disappeared gra-ually; left no streak.	....	From Radiant W........	....	A. S. Herschel.
streak or sparks left...	10°	ϵ Ursæ to γ Persei. Radiant $N_{9, 10}$.	....	Id.
treak or sparks left...	6°	From Radiant M G_3 ...	....	Id.
a smoky streak	....	....	Rate of frequency one meteor per hour. Clear sky.	W. H. Wood.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. July 20	h m Between 12 15 and 12 30 a.m.	Manchester ...	=1st mag.*	White	½ second	Just above β An dromedæ.
20	11 3 p.m.	Birmingham ...	=2nd mag.*	Blue	0·3 second ...	α= δ= From 220°+44° to 205 +36
21	Between 12 0 and 12 20 a.m.	Manchester ...	=2nd mag.*	White	0·75 second ...	Near γ Cassiopeia
21	11 31 p.m.	Birmingham ...	=1st mag.*	White	0·5 second ...	From α Cygni α Lyræ, and further.
21	11 37 p.m.	Ibid	=2nd mag.*	Ruddy	0·5 second ...	From ζ Cygni to Delphini.
23	Between 11 50 p.m. and 12 20 a.m., 24th.	Manchester ...	Brighter than a 1st mag.*	Dull	1 second	4° below α Pegas
25	10 12 p.m.	Birmingham ...	=1st mag.*.........	White	1·5 second ...	α= δ= From 263°+ 9° to 257 −12
28	12 5 a.m.	Ibid	=Sirius	White	3 seconds......	From η to γ Peg
28	12 36 a.m.	Ibid	=2nd mag.*	Blue	0·25 second ...	From η to ε Peg
28	11 55 p.m.	Ibid	=3rd mag.*	Dull white ...	0·75 second ...	From μ to Boötis.
28	11 58 p.m.	Ibid	=3rd mag.*	Blue	0·25 second ...	From β Boötis α= δ= to 210°+43
29	11 31 p.m.	Manchester	=Mars	Bluish white...	½ second	About 1° abov Ursæ Majoris
30	10 45 p.m.	Ibid	=2nd mag.*	Bluish white...	0·75 second ...	Passed 5° be Polaris.
Aug. 4	11 4 p.m.	Birmingham ...	=Sirius	White	0·5 second ...	From α Cassiop to α And medæ.
5	9 53 p.m.	London	=2nd mag.*	Bluish white...	0·75 second ...	From 1° above φ Cygni.
5	10 2 p.m.	Ibid	Larger than ♃ ...	Chiefly orange, varied.	....	Disappeared ne Ophiuchi.
5	10 10 p.m.	Ibid	=α Lyræ...........	White like α Lyræ, then pale orange.	....	Disappeared above α An medæ.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Left no train	2°; short path.	Directed from α Cygni	Two other meteors, 1st and 2nd magnitudes, from this Radiant, or from B_1, or N_{11}.	R. P. Greg.
Left no train	....	From Radiant B_3, in Draco.	Rate of frequency one meteor per hour.	W. H. Wood.
Left a train	6°...........	Directed from Lacerta. From Radiant B G or Q G_1.	One other meteor recorded in this interval; from Radiant A_9 or T_1.	R. P. Greg.
Left a white train on its whole course.	....	From Radiant B_4, in Cygnus.	On the 15th the sky was clear; no meteor seen.	W. H. Wood.
Left a train	....	Directed from ε Cassiopeiæ.	....	Id.
Expanded as a misty flash of light.	Stationary ..	From Radiant T_1	Seven other meteors in the interval; from Radiants A_{10}, B_1, N_{11}. Three meteors in the same interval on the 24th; from Radiants H, T_1.	R. P. Greg.
Left a white train 20° long	....	Directed from ε Cassiopeiæ.	On the 16th and 17th the sky was cloudy, except overhead; no meteor seen.	W. H. Wood.
Left a train 20° long	....	From Radiant B_4, in Cygnus.	On the 29th the sky was clear;—no meteor seen. A marked absence of meteors during the month.	Id.
....	....	From Radiant A_{10}, in Perseus.	....	Id.
Left a train 10° long	....	....	....	Id.
....	....	From Radiant Q, G......	Overcast till 11h 30m p.m. Afterwards two meteors in 40 minutes.	Id.
Misty appearance, like a flash.	Short course; 3°	Directed from γ Draconis.	....	R. P. Greg.
....	5°...........	Directed from η Persei (Radiant A_{10}).	....	Id.
....	....	From Radiant N_{11}, in Cassiopeia.	....	W. H. Wood.
....	....	....	A meteor of the August shower; moonlight; sky much overcast.	T. Crumplen.
....	12° or 15°	On a line from γ Aquilæ to ζ Ophiuchi.	....	Id.
...a broken streak of light visible for 2 secs., seen through fine clouds.	5°...........	On a line from Polaris to ½° above α Andromedæ.	....	J. Dow, Jun.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. Aug. 8	h m s 9 49 p.m.	Birmingham ...	= 2nd, then > 1st, and then = 3rd mag.*	Blue, white, dark.	2·5 seconds ...	α= δ= From 180°+65 to μ Serpentis
8	Between 10 30 and 11 0 p.m.	Whitby (Yorkshire).	= 1st mag.*	White	0·75 second ...	Appeared first below β Arie
8	10 33 p.m.	Birmingham ...	Brighter than 1st mag.*.	Yellow	0·5 second ...	From ρ Piscium wards β Ceti
9	0 22 a.m.	Ibid	= Sirius	Dark blue; then brilliant blue.	1·5 second ...	α= δ= From 275°+7 to η Herculi
9	Between 10 0 and 11 30 p.m.	Whitby (Yorkshire).	Brighter than Sirius	Reddish; bluish-white sparks.	2 seconds......	Centre of path (α, β) Ceph
9	10 5 25 p.m.	Highfield House Observatory, Beeston.	= 2nd mag.*	....	....	From ε Peg crossed ε rii.
9	10 6 p.m.	Birmingham ...	= 1st mag.*	White	0·5 second ...	From ½ (ε, θ gasi to quarii.
9	10 12 40 p.m.	Highfield House Observatory, Beeston.	....	....	....	Passed 5° Delphinus.
9	10 13 p.m.	Birmingham ...	= 1st mag.*	Green	0·3 second ...	From β to θ
9	10 17 2 p.m.	Highfield House Observatory, Beeston.	Twice as bright as a 1st mag.*	Intense blue...	Very rapid ...	Commenced Pegasi.
9	10 18 p.m.	Ibid	= 1st mag.*	Green	0·3 second ...	From ν Andr α= to 353°+
9	10 21 p.m.	Airth, Falkirk (Scotland).	= 3rd mag.*	Whitish	1·25 sec.; slow speed.	From 4° β Pegasi (α, β) peiæ.
9	10 46 p.m.	Highfield House Observatory, Beeston.	Brighter than 1st mag.*.	Blue	....	Appeared under P and pass tween δ, Majoris.

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
At first equal 2nd magnitude star; it then disappeared; and on reappearing became brighter than a 1st magnitude star. It then decreased to a 3rd magnitude star, at the same time changing its colours. Left a train 30° long for $1\frac{1}{2}$ second.	80°	From Radiant V, in Ursa Major.	From between δ and ϵ Boötis to the end of its flight it appeared as a cloudy falling cinder.	W. H. Wood.
Left a momentary streak...	4°...........	Directed from γ Persei. From Radiant A_{10}.	Three meteors in 30 minutes from about the Radiant A_{10}; one from the direction of ϵ Cassiopeiæ.	R. P. Greg.
....	More than 10°. (Intercepted view.)	From Radiant A_{10}, in Perseus.	Fourteen meteors in two hours. Clear sky; one observer.	W. H. Wood.
irst appeared as a 2nd magnitude star; then disappeared, and reappeared as bright as Sirius. Left a train.	....	Directed from ϵ Cassiopeiæ.	The meteor showed intermittent light.	Id.
....	20°	Directed from δ Cassiopeiæ. The Radiant on this night well defined, 3° or 4° from χ Persei, towards Ursa Major, and slightly lower down, at 11^h p.m.	Fourteen 1st, 2nd, and 3rd magnitude meteors recorded in $1^h\ 30^m$. Moon setting; sky beautifully clear: on the night of the 10th cloudy, with slight rain.	R. P. Greg.
....	....	....	[See Appendix I.]	E. J. Lowe.
....	....	....	[Identical with the last]	W. H. Wood.
....	5°...........	Directed from 5° above χ Cassiopeiæ.	[See Appendix I.]	E. J. Lowe.
ft a train	....	Directed from ϵ Cassiopeiæ.	[Identical with the last]	W. H. Wood.
t a long streak	....	Directed from a point 5° above χ Cassiopeiæ.	Some cloud afterwards for 20 minutes.	E. J. Lowe.
t a green train	....	Directed from γ Persei	[Identical with the last. See Appendix I.]	W. H. Wood.
....	25°	From Radiant T, in Pegasus.	For a meteor moving from east to west, the motion was extremely slow.	F. Howlett.
a very long streak ...	....	Directed from a point near and above Cassiopeia.	[See Appendix I.]	E. J. Lowe.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. Aug. 9	h m s 10 47 30 p.m.	Birmingham ...	=1st mag.*.........	Yellow	0·5 second ...	Commenced at Camelopardi.
9	11 1 p.m.	Airth, Falkirk, Scotland.	=Sirius	Orange yellow	....	From 4° below and 2 Cassiopei to 10° below P laris.
10	12 0 2 a.m.	Highfield House Observatory, Beeston.	=2nd mag.*	Colourless ...	....	Shot across Drac
10	12 2 0 a.m.	Birmingham ...	=1st mag.*.........	Yellow	1 second	From Polaris to Draconis.
10	9 43 p.m.	London	=2nd mag.*	....	0·75 second ...	From γ Aquilæ λ Antinoi.
10	9 45 p.m.	Hawkhurst (Kent).	=2½ mag.*	....	....	From α Lyræ t Ophiuchi.
10	9 58 50 p.m.	Highfield House Observatory, Beeston.	....	... .	....	In sword handle Perseus.
10	10 36 p.m.	London	=2nd mag.*	White	....	Commenced at Capricorni.
10	10 37 p.m.	Hawkhurst (Kent).	=α Aquilæ	....	....	Passed between Herculis and Ophiuchi.
10	10 46 p.m.	Birmingham ...	=3rd mag.*	Blue	0·5 second ...	From θ Piscium α= δ= to 338°— 5
10	10 46 p.m.	Winchfield (Hants).	=3rd mag.*	White	....	Shot across gasus into I phinus.
10	11 3 45 p.m.	Highfield House Observatory, Beeston.	6×♃	Blue	....	From 10° belo Aquilæ, fell d the Milky Wa
10	11 6 30 p.m.	Winchfield (Hants).	=♃	Bluish white...	....	Shot across phinus into S.E.
10	11 7 p.m.	Birmingham ...	=Sirius	Orange	1·5 second ...	From θ Aq to φ Capr corni.
10	11 8 45 p.m.	Hawkhurst (Kent).	=2nd mag.*, then =Sirius.	White, then green.	....	From ν Del to ⅓ (θ Aq ε Aquarii).
10	11 33 p.m.	Birmingham ...	=2nd mag.*	Yellow	0·5 second ...	From β to ½ (Pegasi.
10	11 33 10 p.m.	Winchfield (Hants).	=1st mag.*.........	White	....	Shot across γ conis towar Herculis.
10	11 35 p.m.	Hawkhurst (Kent).	=2nd mag.*	....	....	First appeared Draconis, p under e, and appeared a Herculis.
10	11 54 30 p.m.	Winchfield (Hants).	=1st mag.*.........	White	....	From η Ursæ joris to Arct

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
Left a train	25°	Towards β Ursæ Majoris.	[Identical with the last]	W. H. Wood.
Left a greenish train	....	....	Nine 1st-, 2nd-, and 3rd-magnitude meteors recorded in fifty minutes by two observers. Night of the 10th very cloudy. A few bright meteors seen.	F. Howlett.
....	....	Directed from Cassiopeia.	[See Appendix I.]	E. J. Lowe.
.eft a train	....	Directed from ϵ Cassiopeiæ.	[Identical with the last]	W. H. Wood.
....	....	....	[See Appendix I.]	T. Crumplen and J. Dow.
....	....	....	[Identical with the last]	Communicated by A. S. Herschel.
,ike a blue flash of distant lightning not more than 40′ in diameter; very remarkable.	Stationary ..	Radiant in Cassiopeia, or Perseus.	Appeared and disappeared without moving.	E. J. Lowe.
....	5°	Directed from ϵ Equulei	[See Appendix I.]	T. Crumplen and J. Dow.
əft a long train..........	....	....	[Identical with the last (?).]	Communicated by A. S. Herschel.
....	....	....	[See Appendix I.]	W. H. Wood.
....	....	....	[Identical with the last]	C. H. Griffith.
ft a long train of separate sparks, which lingered after the meteor had vanished.	....	....	Very large globe meteor	H. L. P. Lowe.
ft a train which lasted 8 seconds.	....	....	[See Appendix I.]	C. H. Griffith.
ift a train	....	From Radiant $T_{2, 3, 4}$, in Pegasus.	[Identical with the last, or (?) with the next.]	W. H. Wood.
ft a very long and slender streak.	....	....	....	Communicated by A. S. Herschel.
't a train	....	Directed from γ Persei.	[See Appendix I.]	W. H. Wood.
't a long train	....	....	[Identical with the last]	C. H. Griffith.
t a slender train	....	....	[Identical with the last recorded at Birmingham (?).]	Communicated by A. S. Herschel.
t a train	....	Described a curve in its course.	....	C. H. Griffith.

Date.	Hour.	Place of Observation.	Apparent Size.	Colour.	Duration.	Position, or Altitude and Azimuth.
1868. Aug. 10	h m s 11 56 p.m.	Hawkhurst (Kent).	Brighter than α Lyræ.	....	....	Between ε Cep and α Cygni.
11	12 8 a.m.	Birmingham ...	Brighter than ♃...	Green	1 second	From γ Cephe α= δ= to 251°+60
11	12 8 30 a.m.	Winchfield (Hants).	=♃..................	White	....	From τ Cassiop to δ Ursæ joris.
11	12 22 30 a.m.	Ibid..............	=♃..................	Blue	....	From α Draconi β Boötis.
11	11 25 a.m.	Birmingham ...	=♀..................	Orange and green.	1·5 second ...	From ξ Draconi α=254°, δ= 31°.
11	9 37 p.m.	Ibid..............	= Sirius	Blue	1·5 second ...	From ν Androm to α=35°, δ= 60°.
12	9 56 p.m.	Hawkhurst (Kent).	= Sirius	Yellow	....	From ⅓ (ε, θ) gasi to clos and east o Aquarii.
12	10 40 p.m.	Whitby (Yorkshire).	=3rd mag. *	Dull	0·75 second ...	From Lacerta wards Aries.
14	Between 11 10 and 11 50 p.m.	Ibid..............	=1st mag. *	White	1 second	About 3° abo Ursæ Majori
15	11 20 p.m.	Ibid..............	=1st mag. *	Reddish	0·75 second ...	4° above Cor C
15	About 11 20 p.m.	Hawkhurst (Kent).	=3rd mag. *	White	3 seconds; slow speed.	From 5° bef to 5° be α Draconis crossing stars.

APPENDIX.

I. (*a*) Heights of August Meteors observed in England in 1868.

Simultaneous observations of the August meteors in 1868 were made by observers at several British stations, for the purpose of ascertaining the real altitudes of the meteors. The course of the shower was, for the most part, seen under favourable circumstances; and a number of shooting-stars were observed, the apparent paths of eleven of which were recorded simultaneously, at distant places, with sufficient accuracy to enable their heights to be approximately known. The double observations of shooting-stars, and those of other meteors of the shower presenting characters of peculiar interest, are

Appearance; Train, if any, and its Duration.	Length of Path.	Direction; noting also whether Horizontal, Perpendicular, or Inclined.	Remarks.	Observer.
No train or sparks	2° or 3°; very short path.	Towards the Milky Way, parallel to ζ, ϵ Cephei.	....	Communicated by A. S. Herschel.
Left a brilliant green train 15° long, a portion of which, between ζ and η Draconis, remained visible for 30 seconds.	....	Directed from Cassiopeia.	[See Appendix I.]	W. H. Wood.
Left a train for 3 seconds..	....	....	[Identical with the last]	C. H. Griffith.
Left a train which lasted 10 seconds.	....	....	....	Id.
Left a brilliant train for 30 seconds (see figure in Appendix).	....	....	....	W. H. Wood.
Left a white train	....	From Radiant T_1.........	Sixteen meteors counted in three hours and thirty minutes. Sky hazy and occasionally overcast; one observer. Night of the 12th overcast.	Id.
Disappeared suddenly; left no train.	....	....	Sixteen meteors recorded in two hours; 1st and 2nd mags.; mostly with trains.	Communicated by A. S. Herschel.
....	5°...........	Perpendicularly down...	The sky was overcast at Whitby on the nights of the 10th and 11th of August.	R. P. Greg.
Increased from a point ...	½°; very short path.	Nearly stationary	Eight meteors recorded in forty minutes.	Id.
....	1°; nearly stationary.	Directed from ϵ Ursæ Majoris.	....	Id.
Disappeared for half a second, and reappeared further on.	15°	W. to E.	A similar intermittent meteor, 4th mag., preceded it, moving from W. to E. in Sagittarius.	A. S. Herschel.

entered in the present Catalogue. The general results of the observations, and the remarks of observers on the principal appearances of the shower recorded during the times of the simultaneous watch, are included in the paragraphs of this Appendix.

At the *Royal Observatory, Greenwich**, a watch was maintained for the August meteors from the 7th to the 13th by Messrs. Nash, Wright, Trapaud, Farncomb, and Schultz, with the following results:—On the 7th there were

* The observations made at Greenwich will be printed *in extenso* in the forthcoming volume of the "Results of Magnetical and Meteorological Observations at Greenwich" for the year 1868.

twelve meteors observed, twenty-one on the 8th, none on the 9th, the sky being overcast, twenty-five on the 10th, eleven on the 12th, and eleven on the 13th, making a total for the seven nights of eighty meteors, of which no fewer than fifty-two are referable to Radiant A_{10}. It was considered that the meteors were unusually scanty in number on all these nights.

At the *Radcliffe Observatory, Oxford*, on the evening of the 8th of August six meteors, and on that of the 9th four meteors were observed, the sky on these nights being frequently obscured by clouds. On the night of the 10th the sky became clear at 9^h P.M.; but in the first forty-five minutes, although a strict watch was kept, no meteors were observed. In the interval between 9^h 45^m P.M. and 1^h 20^m A.M. on the 11th, the paths and other particulars of fifty-six meteors were recorded by Mr. Lucas. At about 11^h P.M., faint auroral streamers near the Milky Way were observed by Mr. Main; and several distant flashes of lightning were seen, during the next hour, in a quarter of the horizon where the sky was free from clouds.

On the night of the 11th, Mr. Lucas, watching alone, recorded twenty-six meteors in the space of three hours and a quarter, between 9^h P.M. and 12^h 15^m A.M. on the 12th; a thick haze then sprang up, through which only the largest stars could be discerned.

On the night of the 12th the clouds cleared off at about 11^h P.M.; and in the space of 2^h 23^m, between 11^h 17^m P.M. and 1^h 40^m A.M. on the 13th, Mr. Lucas, watching alone, again recorded twenty-six meteors.

At *Highfield-House Observatory, Beeston*, Mr. Lowe observed twenty-six meteors, and recorded the paths and instants of their appearance to the nearest second of Greenwich time, between 9^h 30^m P.M. and midnight, on the evening of the 10th. Twenty other meteors were observed, of which no record was included in the list. In the earlier part of the evening the sky was overcast, and a thunder-storm commenced at 6^h A.M., on the 11th, with abundant rain (2 inches falling during the day), which put an end to the long previous drought. "The meteors were most abundant between 10^h P.M. and 10^h 15^m P.M., and there were several points of convergence: one in the sword-handle of Perseus, and another slightly north of and above Cassiopeia, accounted for most of the meteors. The paths were very short in all meteors seen near these points; those meteors in Ursa Major and Ursa Minor, and in S. and S.W., had very long paths. All were *blue* or colourless, mostly intense blue, and nearly all had streaks, were very rapid in their movements, and vanished instantaneously. From 11^h P.M. clouds and moonlight interfered much with the observations. The meteor at 9^h 58^m 50^s* was very remarkable. During the last few days there have been several large meteors each evening between 9^h 15^m P.M. and 10^h 15^m P.M."

On the night of the 11th the sky was entirely overcast.

At *Birmingham*, on the night of the 8th of August, the sky was clear from 9^h 50^m P.M. until 11^h 50^m P.M., and Mr. W. H. Wood, observing alone, recorded fourteen meteors in two hours. Two of these meteors exhibited intermittent light.

On the night of the 9th the sky became clear soon after 9^h 30^m P.M., and forty-one meteors were recorded by Mr. Wood in three hours. Between 11^h 20^m P.M. and midnight there was a remarkable scarcity of meteors, two meteors only being seen in forty minutes.

The sky became clear on the night of the 10th at ten o'clock, and forty-two meteors were recorded by Mr. Wood, observing alone, in two hours and

* Described at length in the Catalogue, and in Mr. Lowe's MS., at the end of this Report.

a half. Frequent flashes of lightning were seen after 11^h 15^m P.M., apparently beyond the horizon, between the north and west. Two of the brightest meteors, on this night, appeared at 12^h 8^m and 12^h 25^m A.M. of the 11th.

On the night of the 11th the sky was clear of clouds but hazy between 10^h 15^m P.M. and 11^h 35^m P.M., and meteors were not so frequent as on the previous night. In the half hour following midnight none were visible.

The largest meteor observed during the display appeared at 12^h 25^m A.M. on the 11th. This meteor was as bright as Venus, of orange and green colour, and left in its course an emerald-green massive-looking train, 14° long and 6′ broad (see fig. 1). After ten seconds it assumed a serpentine form (fig. 2), and shortened itself some 4°. Eventually the extremities turned round westwards, forming the segment of a circle, almost at right angles to the meteor's original course (fig. 3). It remained visible upwards of half a minute.

Fig. 1.

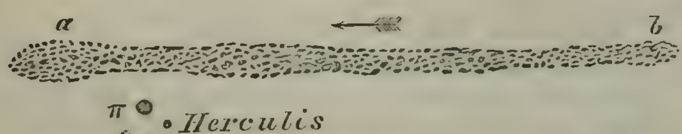
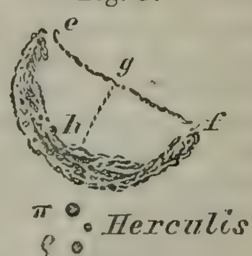


Fig. 2.

Fig. 3.



Changes of a meteor-streak, 1868, August 11th, 12^h 25^m A.M.

1. At first appearance, $ab = 14°$, width $= 6'$.
2. After 10 seconds, $cd = 10°$; vertical height of undulation $= 45'$.
3. After 20 seconds, $ef = 5°$; $gh = 2°$. Total duration more than 30 seconds.

The following is a general summary of the results with regard to the numbers, magnitudes, colours, &c. of the meteors observed by Mr. Wood on the several nights:—

Date, 1868, August	Interval, G. M. T., from h m	to h m	No. of meteors seen by one observer.	Average No. per hour for the night.
8th	9 50 P.M.	11 50 P.M. ..	14 ..	7
9th to 10th	9 30 „	10 30 „ ..	22	
	10 30 „	11 30 „ ..	9	.. 14
	11 30 „	12 30 A.M. ..	10	
10th to 11th	10 30 „	11 30 P.M. ..	23	.. 17
	11 30 „	12 30 A.M. ..	18	
11th to 12th	9 0 „	9 30 P.M. ..	1	
	10 30 „	11 30 „ ..	10	.. 7
	12 0 „	12 30 A.M. ..	3	

List of Radiant-points in simultaneous activity.	Percentage of the whole number of meteors, directed from each Radiant.		Contemporaneous Radiants of former August meteoric showers, quiescent in 1868.
η Persei	30	100.	
γ Persei	20		δ Camelopardi.
ϵ Cassiopeiæ	20		k Persei.
B_4, B_5	10		N_{11}, (H), B G, B_3.
$N_{12, 13}$	5		Q_3.
$T_1, T_{2, 3, 4}$	5		E.
Q G	9		R_1, R_2.
Undetermined	1		

Percentage numbers of the whole, with regard to apparent magnitudes and colours :—

As bright as	Venus,	Jupiter,	Sirius,	1st-mag.*,	2nd do.,	3rd do. and under.
Percentage Numbers.	1	4	12	30	24	29
	9	10	34		47	

Colours :—white, green, yellow & orange, blue.

40 per cent. of the meteors left persistent trains.

"From the foregoing numbers it will be seen that the shower differs in many particulars from those previously recorded, in accuracy of radiation, presenting fewer radiant-points and a less confused appearance; while the presence of green, yellow and orange, and of train-bearing meteors in such large proportions makes it conspicuously different from the August meteor-shower in 1866 (*vide* Report for that year, p. 141). The radiant ϵ Cassiopeiæ produces nearly the same percentage number of meteors, and the proportion of 1st- and 2nd-magnitude meteors is nearly the same, as in the August shower of 1867 (*vide* Report for that year, p. 409). On the other hand, the hourly numbers are double of those in 1867, and agree more nearly with those observed in 1866." A list of the apparent paths of the foregoing meteors (some of which, recorded in R.A. and Decl., and by alineations with the neighbouring fixed stars, are entered in the present Catalogue) accompanies Mr. Wood's Report.

At *London*, the sky was completely overcast on the 9th. On the night of the 10th, Mr. T. Crumplen, assisted by Mr. J. Dow, counted 41 shooting-stars in two hours, between 9^h and 11^h P.M., the following numbers of the meteors being recorded in the successive half hours ending—

1868, August 10th,	$9^h\ 30^m$,	10^h,	$10^h\ 30^m$,	11^h	
No. of meteors seen by two observers.	9	15	9	8	Total 41.

The sky, which was partially obscured at $10^h\ 30^m$, became totally so at 11^h P.M., and prevented further observations.

"These meteors, with two exceptions, were all from the radiant-point near β Camelopardi. There was a marked absence of shooting-stars from other radiants. The whole were accompanied by luminous trains, which faded from the ends towards the centre, being broadest in the middle, as in previous years. In some cases, perhaps in most, they only attained their full breadth after the disappearance of the meteor. The general colour was white, inclined perhaps to orange. The average length of path was not less than 15°. . . . . . The uniform appearance of the meteors was a striking feature of the shower."

Clouds presented themselves on the nights of the 11th and 12th, only one other meteor being observed on the latter date.

On the night of the 13th, two bright and five smaller meteors were noted in forty-five minutes, radiating from near δ Cassiopeiæ. From this radiant-point, also, the two exceptional meteors observed on the night of the 10th were directed.

At *Hawkhurst*, on the nights of the 9th and 11th, the sky was overcast. In two hours and a half, between $9^h\ 30^m$ and 12^h P.M. on the night of the 10th, twenty-three meteors were registered, and many others were seen, of which the particulars were not noted. The brightness and colours of the meteors recorded were as follows:—

As bright as	Jupiter,	Sirius,	1st-mag. *,	2nd do.,	3rd do. and under.
No. of meteors noted.	2	3	8	5	3
	4	1	3	1	
Colours:—	white,	green,	yellow,	red.	

Of two of these meteors, which appear to be certainly identified with meteors observed at London, the real heights are given (see Nos. 6, 7 in the Table) at p. 385 of this Report.

On the night of the 12th, seventeen meteors were recorded in the two hours preceding midnight, of several of which the brightness and colours were noted as follows:—

As bright as	Sirius,	1st mag.*,	2nd do.,	3rd do. and under.
No. of meteors noted.	3	7	5	1
	2	..	1	..
Colours:—	white,	green,	yellow,	red.

At *Winchfield, Hants*, Mr. C. H. Griffith observed between 10^h P.M. on the 10th and $1^h\ 22^m$ A.M. on the 11th, the apparent paths and instants of appearance of thirty-nine meteors. Ground-fog and clouds having then spread over, prevented further observations. The apparent sizes and colours of the meteors were recorded thus:—

As bright as	Jupiter,	1st-mag. ,	2nd do.,	3rd do.,	4th do. and under.
No. of meteors recorded.	6	9	9	6	8
	25	3	2		
Colours:—	white,	bluish,	red.		

Eleven of the meteors left luminous streaks. Four meteors of the list are identified as having been simultaneously observed by Mr. Wood at Birmingham.

At *Sunderland*, Mr. T. W. Backhouse watched for the meteors on the nights of the 7th, 8th, and 9th of August. "The sky was clear on the latter night, and thirty-five meteors were recorded, all of which, with only three or four exceptions, appeared to be conformable. The meteors came very irregularly; they seemed most frequent from $10^h\ 40^m$ to $11^h\ 10^m$ P.M. Their average rate of frequency was about twenty-two per hour. The radiant-point was about R.A. $2^h\ 45^m$, N. Decl. 53°. Most, or all of the bright ones left trains."

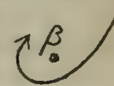
On the nights of the 10th and 11th the sky was overcast.

At *Wisbeach, Cambridgeshire*, the sky was cloudy on the 9th, and three meteors radiating from Cassiopeia were observed. On the night of the 10th the sky was cloudless, and Mr. S. H. Miller noticed a shower of bright meteors leaving long trains, which were brightest at the middle of their length. On the night of the 11th the sky was again overcast.

At *Cambridge* the shower was seen to great advantage on the night of the 10th, by Mr. G. Forbes; and a number of the meteors were referred to

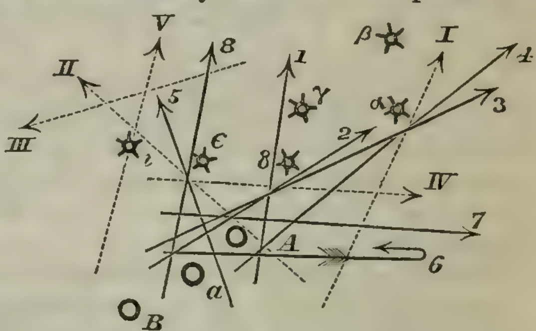
the constellations in the neighbourhood of Cassiopeia, to determine the exact position of the radiant-point.

"The night was remarkably clear; and many meteors were seen before beginning to record them. There were no large meteors; and none burst. The trains were in general very short, if not merely optical illusions *. When a nucleus was visible it usually *passed beyond the end of the train,* being extinguished suddenly, apparently *without previous diminution of size.* Two meteors *described curves*—the first an open curve, and the second thus,  (see fig., no. 6). A similar meteor to the last was observed on the 21st of October, 1866, when a meteor traced a curve round β Aurigæ thus,



No meteors came from the radiant that I found last year in Pisces.

"Attention was chiefly confined to determining the position of the radiant-point from paths of meteors chiefly close to Cassiopeia. The point appears to be as nearly as possible at R.A. $2^h\ 16^m$, N. P. D. 31°.



"The meteors always came *several at a time,* and then a pause. Those that came together were usually in the same part of the heavens." The following numbers of meteors were counted in the successive quarters of an hour ending at—

Date and Hour, 1868, August	10th (P.M.), 11h.				11th (A.M.), 12h.				1h.
	9^m	24^m	39^m	54^m	9^m	24^m	39^m	54^m	11^m
Number of conformable meteors.	3	13	6	3	3	3	5	5	6

Total number of conformable meteors .... 47 Average hourly number, 20.
Number of erratic meteors 6

Total number seen in $2^h\ 16^m$ 53

"On the night of the 11th–12th the sky was clear after half-past 11, but the moon too bright for observations after 1 o'clock. The paths were very short, and only five were near enough to the radiant to be mapped (represented by dotted lines in the figure, I. to V.). These are quite discordant; but it appears that the radiant of yesterday is not that of to-day, A being the position of yesterday's and B about that of to-day's. Yesterday it was remarkable how much truer to the radiant-point the meteors were than last year †; to-day seven, at the very most, came from about A, nearly all whose directions I could produce backwards coming from nearer to B.

"Two meteors on this night appeared to pass beyond their trains with undiminished brilliancy, till they were suddenly extinguished; they were, however, too rapid and short-lived for me to be perfectly certain about it." One such meteor was observed at $12^h\ 33^m$; the train of another meteor, which appeared at $12^h\ 37^m$, and which was very bright, appeared to be broken in the middle. The streak only lasted half a second.

The following numbers of the meteors were counted in the successive quarters of an hour ending at—

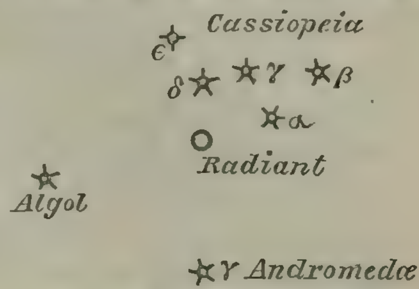
* The brightness of the moonlight may have diminished, in some degree, the apparent brightness and duration of the streaks.

† In the figure, *a* is the position of the radiant for 1867, Aug. 10—at R. A. $2^h\ 43^m$, N. P. D. 29° 30′.

Date and hour, 1868, August	11th (P.M.) $11^h\ 57^m$	12th (A.M.), $12^h\ 12^m$	27^m	44^m	Total numbers.	Average number per hour.
Number of conformable meteors.	4	3	5	5	17	16
Do. erratic.	1	1	0	2	4	

At *Airth*, near *Falkirk*, in Scotland, the apparent paths of nine meteors were recorded, and three other shooting-stars were seen, by Mr. Howlett, during the hour from 10^h to 11^h P.M., on the evening of the 9th.

"The courses of all but two, which radiated from Pegasus, were directed from a point in the midst of a triangle formed by Algol, γ Andromedæ, and Cassiopeia, as shown in the accompanying figure—or at the centre of the quadrilateral formed by those two stars with the extreme bright stars (β and ϵ) of Cassiopeia.



"Clouds and a dense haze overspread the sky so thickly on the night of the 10th, that only three bright meteors could be distinguished through the fog, between 10^h and 11^h P.M., clearly indicating, however, a considerable activity of the shower."

Heights of the meteors simultaneously observed.—On comparing together the observations made at the several stations, eleven meteors are identified, from the list, as having been simultaneously observed at two stations, whose names are indicated, for shortness, in the following Table, by their initial letters, viz. Birmingham (B.), Hawkhurst (Ha.), Highfield House Observatory (Hi.), London (L.), Winchfield (W.). The corresponding observations are placed in the foregoing Catalogue; while the times of appearance recorded at the first place of observation, and the particulars of apparent size and train observed at both stations, are entered in the following Table. The real heights at first appearance and disappearance, and the directions approximately calculated from the observations by means of graphical projections of the apparent paths recorded at the two stations, are entered in the last columns of the Table.

Table of Heights of August Meteors observed in England in 1868.

Date. 1868, Aug.	Time of appearance at first station, G. M. T.	1st station.	2nd station.	Apparent size as per stars.		Appearance of train and its duration.		Height in B. S. miles at		Approximate radiant-point, and remarks.
		I.	II.	I.	II.	I.	II.	1st appearance.	Disappearance.	
	h m s									
9th	10 5 25 P.M.	Hi.	B.	2	1	with	with	105	47	ϵ Pegasi.
,,	12 40 ,,	Hi.	B.	...	1	...	with	65	38	η Persei.
,,	17 2 ,,	Hi.	B.	1+	1	with	with	57	52	Telescopium.
,,	46 0 ,,	Hi.	B.	1+	1	with	with	60	50	Aries.
10th	12 0 2 A.M.	Hi.	B.	2	1	...	with	67	43	γ Andromedæ.
,,	9 43 0 P.M.	L.	Ha.	2	2	...	...	69	51	χ Persei.
,,	10 36 0 ,,	L.	Ha.	2	1	...	with	29	23	A very doubtful accordance.
,,	46 0 ,,	B.	W.	3	3	...	...	93	59	Perseus. See *infrà.*
,,	11 7 0 ,,	B.	W.	Sirius	♃	with	8 secs.	54	41	Perseus. See *infrà.*
,,	33 0 ,,	B.	W.	2	1	with	with	80	52	See *infrà.*
11th	12 8 0 A.M.	B.	W.	♃	♃	20 secs.	3 secs.	101	42	Cassiopeia. See *inf.*

The observations of No. 7, although agreeing well together, exhibit such a considerable parallax as to make the reality of the accordance, if possible,

still very doubtful. The apparent paths of the meteors 8, 9, 10, as recorded at Birmingham, require to be prolonged towards the points of disappearance, and to be shortened at the points of first appearance, while opposite corrections nearly equal in amount (about 8°) require to be applied to the apparent paths observed at Winchfield, in order to satisfy the conditions of simultaneous observation. The discrepancy of the observations in each case would be explained by supposing those at Birmingham to have reference to an early view, and those at Winchfield to refer to a view of a somewhat later portion of the visible path of the same meteor.

The direction of the meteor No. 11 relatively to the two stations is not favourable for very exact determinations of its height, which are, accordingly, affected by probable errors of many miles for 1° of error in the observations. The same probable error in the other meteors of the list does not, in any case, exceed 2 or 3 miles.

(*b*) Heights of shooting-stars observed at Göttingen (G.) and Pekeloh (P.) on the night of the 11th–12th of December, 1865, graphically determined by Professor Heis (H.), and calculated by M. Börgen (B.).

Ref. No.	Date, 1865, Dec.	Hour, Göttingen M. T.	Mag. as per stars.		Streak.	Height in B. S. miles.			
						Beginning.		End.	
			G.	P.		H.	B.	H.	B.
		h m s							
1.	11	9 12 30	3	2	with	68	82	56	54
2.	11	39 15	3	4	...	104	97	89	84
3.	11	10 39 30	5	2	with	59	49	36	22
4.	11	57 22	1	1	with	101	103	23 *	63 *

(*c*) Heights and other particulars of the August meteors in 1866, by Professor Heis (Astronomische Nachrichten, July 1867).

The meteors were most abundant on the nights of the 9th, 10th, and 11th; and the position of the radiant-point appeared to vary on successive nights between H. Camelopardi and η Persei. The following heights of meteors were observed at Blumenthal (B.) and Leer (Le.).

Ref. No.	Date, 1866, Aug.	Hour, Münster M. T.	Station where observed.	Mag. as per stars.	Height in B. S. miles.	
					Beg.	End.
		h m s				
1.	9	9 25 5	M., Li.	1, 2	39	28
2.	9	54 7	M., Le.	4, 1	84	65
3.	9	57 49	M., Li.	2, 2	32	25
4.	9	10 7 28	Pa., Pe.	1, 1	143	36
5.	9	21 44	M., Pe.	2, 1	41	31
6.	9	29 9 †	Pa., B.	2, 3	82	41
7.	9	38 5	M., Pa.	1, 3	97	39
8.	9	59 9	Pa., B.	2, 3	180	77
9.	9	11 12 10	M., B.	1, 1	67	18
10.	11	10 41 44	Pa., Le.	1, 2	36	25
11.	11	11 55 49	Pa., Pe.	2, 3	55	37
12.	12	9 58 2	Pa., Le.	2, 2	40	14

* The apparent point of disappearance is regarded as correctly observed at Pekeloh by Dr. Heis, and at Göttingen by M. Börgen; the apparent flight having been recorded as much longer at the former place than at the latter. The great discrepancy of the heights of a meteor, so differently inferred by different computers from the same observations, may, in this way, frequently be accounted for.

† Printed $10^h\ 59^m\ 9^s$ in the 'Astronomische Nachrichten.'

Lippstadt (Li.), Münster (M.), Papenburg (Pa.), and Pekeloh (Pe.). The position of Blumenthal is E. long. 7° 48′·3, N. lat. 53° 11′; and of Leer, E. long. 13° 41′·5 *, N. lat. 53° 15′. The positions of the remaining stations, with a map, are already given in former Reports (for 1863, p. 323; and 1865, p. 125).

II. Aërolites, Large Meteors, and Star-showers.

a. Aërolites.

1. Knyahinya, 1866, June 9, 4^h 56^m p.m. (local time).

Second Report of Dr. Haidinger, with maps, drawings of the stone, and tinted plate of the meteor (Vienna Acad. Sitzungsbericht, vol. liv. pt. 2, Oct. 11, 1866).—In addition to the brilliant fireball, whose light in broad day was like that of a faint flash of reddish lightning, and which was chiefly visible at a distance from the place of fall (Eperies, Rakamaz, &c.; see Report for 1866, p. 133), the following unusual phenomena attended the stonefall. Nearly simultaneously with the appearance of a small bluish cloud in the air over Sztricsava, near Knyahinya, there was heard at that place, and for many miles round, a sharp report, like that of a six-pounder cannon, followed for ten minutes by a rumbling sound like that of water boiling, the rumbling of a cart on a pavement, or of stones striking together. Three or four minutes after the first report stones were seen to fall at various places over an extent of area measuring from N.N.E. to S.S.W. about 9 miles in length, and about 3½ miles in breadth from W.N.W. to E.S.E. The stones when picked up were lukewarm, as if shone upon by the sun †, or even as warm as if taken freshly from an oven. One, of the size of a plum, which fell upon a linen cloth, did not singe it. The smaller stones did not penetrate the earth more than a few inches, or lay upon the surface. One of moderate size, which fell through a tree at the door of the inn at Knyahinya, broke from it a branch half an inch in thickness; and ten such branches were broken by a larger stone, in its fall through an apple-tree, beneath which it was found. Many other stones were seen to fall. That which weighed 73½ lbs. (Austrian) penetrated the firm sandstone-earth of the district to a depth of 2 feet. About 100 paces from it, three weeks after the occurrence, was found a hole 4 feet wide and 4½ feet deep, round which the earth had been scattered to a distance of 30 yards. On sounding the hole a firm stone was discovered at a depth of 11 feet below the surface. The aërolite was exhumed. It was found to be broken across, and, with the remaining pieces discovered in the same hole, weighed about 300 kilogrammes (660 lbs. English). The direction of penetration was from N. 31° E., altitude 63°. Its position, a league N.E. from Knyahinya, occupies the extreme N.N.E. corner of the general area of the fall. Another very large stone is said to have fallen about two miles S.W. from Knyahinya, which could not be discovered. Since the fall of an aërolite related by Pliny to have taken place at Ægospotamos, about 465 b.c., which was a full waggon-load, this is the largest fragment of an aërolite (not including masses of meteoric iron) on record. The following, according to Dr. Haidinger, are the weights (avoirdupois) of the largest recorded specimens of other aërolites, viz. Ensisheim, 280 lbs.; Juvenas, 240 lbs.; New Concord, 103 lbs.; Parnallee, 130 lbs. The two large and two smaller pieces into

* Printed 52° 6′·5 in the 'Astronomische Nachrichten,' *i. e.* 32° 6′·5 E. long. from Ferro.
† And *not*, as stated in Dr. Haidinger's first report, but corrected by later communications, "ice-cold."

which the stone was fractured by the fall are placed in the Geological Museum at Vienna, together with a number of smaller aërolites of the same fall, some of which are perfect specimens of the stones.

Up to the 24th of September, 1866, fragments of which the following are the numbers and weights (Austrian) had been collected on the site of the fall:—

		lbs.
1 fragment		550
5 fragments,	of $73\frac{1}{2}$, 30, 17, 14, 6 lbs., together	$140\frac{1}{2}$
20 ,,	of between 2 lbs. and 4 lbs. ,,	60
50 or 60 ,,	of smaller weights ,,	100
	Total, about 80 fragments, weighing	$850\frac{1}{2}$

Dr. Haidinger estimates that, on a moderate allowance for those which fell undiscovered, at least 1000 aërolites fell, and that the whole mass must have weighed not less than 8 or 10 cwts.

2. Pultusk, Poland, 1868, Jan. 30, 6^{h} 50^{m} P.M. (local time).

Report of Dr. J. G. Galle on the fall, and on the meteor's path in space (Abhandlung der schlesischen Gesellschaft für vaterl. Cultur, March 4, 1868).—A great shower of aërolites took place near Pultusk, 25 miles N. from Warsaw, over a space four and a half miles in length, from Obryte (E. long. 20° 47′, N. lat. 52° 42′) to Siele (E. long. 20° 38′ 30″, N. lat. 52° 47′), in a direction from S.S.W. to N.N.E., and only one mile in breadth. The largest aërolite, weighing 10 lbs., was found at Makoff, the extreme N.N.E. point of the space of fall. Those found at Siele weighed between 3 lbs. and 4 lbs.; and the remaining stones, becoming gradually less towards the S.S.W., weighed on the average 2 lbs., 1 lb., and $\frac{1}{2}$ lb., as far as Obryte, where aërolites of the smallest size only fell, of weights not exceeding $\frac{1}{4}$ lb. The direction and manner of their distribution, it will be seen shortly, coincides nearly, but not quite, with the direction of the meteor's course. The stones are shaped like splintered fragments of a larger mass, rounded at the edges and coated over with a dull, brown or black crust, glittering here and there with grains of metallic iron. In the interior of one perfect aërolite was found a solid piece of metallic iron of the size of a cubic inch.

Ten seconds before the heavy report which accompanied the stonefall at Siele, and $3\frac{1}{2}$ minutes before the sound of the report was heard at Warsaw, an intensely brilliant fireball exploded over the neighbourhood, with such dazzling brightness that it was seen as far as Müllrose (230 B. S. miles), and at Frankfort on the Oder (415 miles from the place of fall). Although the sky was overcast, and even the moon's light was darkened by a snowfall, the illuminating power of the meteor at the latter place was so intense that the light of the gas-lamps in the streets was overpowered. At Weringerode, on the Harz Mountains (also 415 miles from the place of fall), the windows and the outline of a house a mile off could be plainly distinguished by its light, which lasted five seconds, although the meteor there shone at a very small altitude above the horizon. The meteor appeared first as a small shooting-star, gradually increasing in splendour and changing from a star to a conical form, scattering sparks, and leaving a train of carmine colour on its course, until, from a bluish bolide of ordinary appearance, it became a well-defined fireball of red colour, and burst into a shower of sparks, which descended vertically over Siele.

Dr. Galle estimates the height of the explosion at 25 miles above the earth;

and this agrees with the interval between the light and the report at Warsaw (although not quite so well with that observed at Siele). From this point the aërolites descended vertically upon Siele with such slight velocity that none of the stones were buried in the ground. A flight of 115 miles in about $6\frac{3}{4}$ seconds, descending from a height of 160 or 185 miles at first appearance, nearly represents, according to the observations at Breslau and Dantzig, the meteor's real path. The point of radiation (ψ Piscium) is only 23° from the point *opposite* to the "apex of the earth's way." The relative velocity of the meteor with respect to the earth, depending on the duration of its flight, $6\frac{3}{4}$ seconds, which is a mean result of twenty-six independent observations, is 17 miles per second; so that the meteor appears, in its real orbit in space, to have pursued and overtaken the earth directly in its path, with an inclination to the latter of only 11°, and with a real progressive velocity in its course of 35 B. S. miles per second.

The following, according to Dr. Galle, are *the hyperbolic elements* of the orbit of the meteorite, which cannot be reduced within the limits of the parabolic form, unless by nearly doubling the assumed time of the meteor's duration, or by supposing its apparent path at Dantzig to be diminished by nearly one half (from 38° to 20°), a supposition which is not by any means easily reconcilable with the remaining observations:—

Perihelion Passage, 1868, Jan. 22·5.

Long. of perihelion	116°
Long. of ☊	310°
Inclination	6°
Log. perihelion dist.	9·9841
Log. $\frac{1}{2}$ major axis	9·8778
Excentricity	2·277

Motion direct.

A change of the assumed velocity, Dr. Galle adds, would principally affect the excentricity and $\frac{1}{2}$ major axis, without sensibly altering the values of the remaining elements of the orbit.

Report of Dr. Haidinger on the stonefall (Vienna Acad. Sitzungsbericht, vol. lvii. pt. 2. March 1868).—The site of the shower of aërolites, of which the three largest stones weighed respectively 2 lbs., 4 lbs., and 10 lbs., is between Ostrolenka and Pultusk, forty miles N.E. from Warsaw. The smallest of the three large stones is in the Mineralogical Museum at Vienna. It is an equilateral wedge, 2 or 3 inches wide, and 3 or 4 inches long; its faces marked with circular depressions, and glazed over with a thin dull-black crust. In its structure it coincides with Partsch's group of Eichstädt, Barbotan, Timochin, Zebrak, and Gross-Dwina, to which may now be added Zerkon and Bustee, all of which have large contents of iron and a high specific gravity, 3·55–3·70; that of the Siele aërolites is 3·66. Their substance is tufaceous, grey or brown, containing darker spherules intimately admixed with iron and a small quantity of Troilite. A polished section exhibited black lines, with a fine thread of metallic iron running in them, which apparently represent the planes of friction, fissure, or striation not uncommonly met with in terrestrial rocks. Many other stones were picked up on the site of the fall; and the shower of aërolites is supposed by Dr. Haidinger and by Dr. Galle to have entered the atmosphere as a swarm of separate stones, like those aërolitic showers which fell at Barbotan, L'Aigle, Stannern, Orgueil, and Knyahinya.

3. Villa Nova, Casale, Piedmont, 1868, February 29th, 11^{h} A.M. (local time).

Note by P. F. Denza (Bullettino Meteorologico del Coll. R. Alberto di Moncallieri, Turin).—A mass of fire, surrounded by cloud, moving with great velocity, was seen at a considerable height above Villa Nova (E. long. 8° 27′, N. lat. 45° 8′) near Casale. It was followed by two violent detonations, at an interval of a few seconds, and by a prolonged report, like rapid file-firing, which was heard as far as Alessandria, seventeen English miles from Casale. Three stones reached the ground, each of which struck the earth with a heavy sound. The locality of the fall is between Villa Nova and La Mota dei Conti (E. long. 8° 30′). The largest of the stones, weighing about 15½ lbs. avoird. fell north of Villa Nova, and buried itself in the ground to a depth of 14 inches. The second, weighing nearly 3 lbs., struck the earth a mile and a half from the first, a few feet from a peasant, at whose feet it buried itself in the earth to a depth of 20 inches. The third, which was probably ½ lb. or ¾ lb. in weight, struck the ground close to a lady, who witnessed its descent, two miles from the spot where the second stone descended; and it was broken in pieces by the fall.

The second stone presents in its outline a series of sinuosities, while the largest stone is bounded on three faces by plane surfaces, meeting each other at right angles. Its entire surface is coated with a yellowish bronze-coloured glaze, resulting from external fusion of its substance, which is also found on one face of each of the broken fragments of the smallest stone. The freshly fractured surfaces exhibit the interior structure of the aërolite, whitish, and granular in its texture, like fine-grained granite, wherein the microscope reveals throughout a number of bright metallic specks. The stones are strongly attracted by the magnet. Their specific gravity is 3·6.

This is the third shower of aërolites that has occurred in the vicinity of Casale during the last interval of fifty years. A large meteor was observed on the Adriatic coast on the morning of the aërolitic fall, and another large fireball on the evening of the same day at Alessandria.

b. Large Meteor of the 1st January, 1868, 7^{h} 27^{m} A.M. (See Catalogue.)

At *Ropley*, Hampshire.—The appearance of the streak is thus described by Mr. A. Harding:—“The meteor left behind it a luminous train which appeared as a streak of silver in the sky, disjointed about 12° from the point of starting; and in the latter portion two bright spots were visible, the first nearly round, and the second pear-shaped, the tail being still produced about 1° beyond the latter spot. About two minutes after its appearance the former part of the train took a wavy motion, which continued for five minutes, when a cloud intercepted the view. Fifteen minutes after the appearance of the meteor the cloud cleared away, and the streak apparently was as bright as ever; but the cloud again interposed; and when the streak was again seen, at forty-seven minutes past seven, it was perceptibly fading, having lasted fully twenty minutes. At this time the sky became overcast, preventing my seeing the final disappearance of this magnificent meteor.”

At *Southampton*.—Appearance of the streak, as described by Mr. F. L. Wollaston:—“At 7^{h} 30^{m} A.M. there was a perfectly clear sky, except a few clouds very low on the horizon; a slight breath of air, just enough to show its direction by the smoke of chimneys, coming from about N.E. On the disappearance of the meteor there was a narrow line of light throughout the whole of its course. The greater part of this disappeared within a few minutes; but small portions, gradually disappearing, remained, assuming the appearance of very narrow, thin, white clouds. One very short part (say,

about one-thirtieth of the whole course) was visible for forty minutes, until $8^h\ 10^m$, when it disappeared immediately over, and in consequence of the increasing light from, the sun. This short part had been very slowly moving during those forty minutes in an easterly direction, and therefore against the wind as it blew on the surface here."

c. Star-showers.

1. The August Meteors in 1867.

The August meteoric shower, in 1867, was more irregular in the time and place of its appearance, as remarked by M. Quetelet, than it appears to have been observed in any previous year. A great scarcity of meteors about midnight on the night of the 10th was observed at many places, and especially in Italy—at Milan by Prof. Schiaparelli, at Palermo by Prof. Cacciatore, and at Varallo, in Piedmont, by Prof. Calderini. The following are the numbers counted by the latter observer, watching alone, the sky being perfectly clear, and the moon uniformly bright throughout the time of the observations:—

Numbers of meteors observed at Varallo in the hours ending

1867.	10^h P.M.	11^h P.M.	12^h P.M.	1^h A.M.	2^h A.M.
August 9 to 10	6	5	9	9	30
,, 10 to 11	1	7	8	3	0*
,, 11 to 12	9	14	11	11	5*

Two great maxima, however, appear to have occurred—one on the morning of the 11th, and another on the morning of the 12th. The first maximum is recorded by Prof. Ragona in the following Table of observations at Modena, continued to a late hour on the morning of the 11th:—

Numbers of meteors counted at Modena by four observers, in the hours ending

1867.	11^h P.M.	12^h P.M.	1^h A.M.	2^h A.M.	3^h A.M.	4^h A.M.
August 8 to 9	—	11	17	50	24†	—
,, 9 to 10	23	23	57	77	76	—
,, 10 to 11	11	8	59	86	197	67†

A great abundance of meteors towards three o'clock A.M., on both mornings of the 11th and 12th, was also noted by Father Parnisetti, Prof. Porrati, and their assistants at Alessandria, a group of ten or twelve meteors, on the morning of the 12th, sometimes appearing together in one minute. The sky was perfectly clear throughout the observations.

Numbers of meteors observed at Alessandria, by four observers ‡.

1867.	Turin M. T. from h m	Turin M. T. to h m	Interval. h m	Number of meteors counted.	Hourly number of meteors.
August 9 ...	1 10 A.M.	2 10 A.M.	1 0	79	79
,, 10 ...	12 55 ,,	3 0 ,,	2 5	225	108
,, 11 ...	1 50 ,,	3 34 ,,	1 44	262	151
,, 12 ...	2 15 ,,	3 43 ,,	1 28	269	184
,, 13 ...	3 16 ,,	4 0 ,,	0 44	45	61

* Counted in half an hour. After this time observations were discontinued on account of the scarcity of the meteors.

† Counted in half an hour.

‡ This and the previous Tables are taken from the pamphlet by Father F. Denza, 'Le Stelle Cadenti di Agosto osservate in Piemonte nel 1867,' 12mo, Turin, 1867.

"At *Florence*.—Professor Donati reports (Bullettino Meteorologico, September 1867) the following results of observations on the number and time of maximum frequency of the meteors.

Date.	Number of meteors seen during the hour ending at (Florence M. T.)							Total.	No. of Observers.
1867. August.	10^h P.M.	11^h P.M.	12^h P.M.	1^h A.M.	2^h A.M.	3^h A.M.	4^h A.M.		
9 to 10	6	35	25	29	51	61	30	237	3
10 to 11	32	48	39	50	122	160	106	557	4
11 to 12	27	27	30	34	53	94	86	351	3
12 to 13	6	24	12	14	18	28	28	130	2
13 to 14	3	6	6	6	9	7	10	47	1
Total 1322 meteors; 972 conformable.									

"The maximum deduced from this Table was from two to three o'clock on the morning of the 11th of August." (Prof. H. A. Newton, in Silliman's Journal, 2nd ser. vol. xliv. p. 427.)

Radiant-region of the shower.—The area of radiation of the August meteors, as shown by Prof. Twining, appears to undergo changes of its position on successive days; and the same may perhaps also occur in successive years. According to the observations of Mr. R. P. Greg in 1866 and 1867, confirmed by those of Mr. W. H. Wood, the radiant-region in those years appeared to be elongated, or to advance during the shower from near ϵ Cassiopeiæ to near α Persei, the meteors from the former radiant-point appearing to Mr. Greg to be swifter than the rest. A gradual passage from the radiant N_{11} at the foot of Cassiopeia's chair, commencing in July, to that for the 10th of August in Perseus, A_{10}, is possibly an explanation of the peculiar feature, that meteors from the direction of Cassiopeia are visible as early as the 16th and 17th of July, moving very swiftly, and leaving very persistent streaks.

At *Winchendon*, Mass., U.S.A., Mr. F. W. Russell reports that on the 7th of August, 1867, between 9^h 45^m and 10^h 45^m P.M. there were observed "eight meteors, all from a radiant near ϵ and δ Cassiopeiæ." The radiant gradually passed down into Perseus; and on the 11th it was at R. A. 47° 45′, N. P. D. 31°; while on the 12th it was at R. A. 50°, N. P. D. 33°, "having moved towards μ Persei, and a little towards α also. Moreover the area seemed elliptical, the major axis being in declination, and with a ratio to the minor axis of 5 : 2." (Ibid.)

2. The November Meteoric Shower in 1867.

The 'Zeitschrift der österreichischen Gesellschaft für Meteorologie,' vol. iii. No. 3, contains the following announcement of the appearance of the November meteoric shower of 1867 in Europe :—" Some interesting observations on this subject appear in Heis's 'Wochenschrift für Astronomie.' At Vegesack* Dr. C. Behrmann kept watch himself, almost in vain, throughout the whole night until 7^h A.M.; the bright moonlight, and a thick fog which rose up late in the night, prevented him from observing more than a few shooting-stars, which came from the constellation Leo. A friend, however, of Dr. Behrmann, whose attention had been directed to the expected return of the phenomenon, saw the sky at 8^h A.M., on the morning of the 14th, quite overspread with meteors, whose appearance in the increasing twilight and in the thick fog was

* N. lat. 53° 11′, E. long. 8° 40′; near Bremen, on the Weser, in Hanover.

like small swarms of gnats. They seemed to start from a point in the south, and emanated thence in all directions. He even saw some crossing in front of the sun's disk when it was still low upon the horizon. Other persons, to whom it was pointed out, also witnessed the phenomenon. It appears to have been most brilliant at about $8^h\ 30^m$ A.M.; after 9^h A.M. nothing further was perceived.

"'At *Calmar** in Sweden,' according to the 'Ostsee Zeitung,' 'an unusually brilliant star-shower was observed; early in the morning, the Calmarsund was lighted up by thousands of falling meteors.'"

Among the preparations for the display in 1867, a partially successful attempt was made, on the occasion of this return of the November meteors, by M. W. de Fonvielle to surmount the clouds, and to view the shower, at Paris, in Mr. Giffard's "captive balloon." Although the experiment was not carried out on the night of the 13th–14th of November, a still more adventurous voyage, in a free balloon filled with pure hydrogen gas, and lent by Mr. Giffard for the purpose, was commenced at Paris, under the guidance of the same practical observer, M. de Fonvielle, accompanied by M. Jules Godard as aëronaut, and M. A. V. Weyenberch, shortly before midnight on the following evening, and terminated at daybreak on the coast of Belgium. A star-chart, a telescope, a barometer, and other instruments for observation were taken up; and although the height attained did not exceed a few thousand feet, a clear atmosphere was reached, and observations were obtained of several shooting-stars not visible to observers on the earth's surface.

Although the attempt to establish a floating observatory for observing the meteoric display on the morning of the 14th of November last was obliged to be abandoned, yet the experiment of the following night successfully proved that the hindrance of clouds to the observation of shooting-stars can be removed by means of balloon ascents on rare and important occasions of their appearance. Ascents in balloons for scientific purposes, if arranged to take place by night on the periodical star-shower dates of the 10th of August and 14th of November, might, on account of the extensive horizon visible from such a great elevation, be the means of tracing to their origin in distant meteors the unaccountable flashes of light "like distant lightning" which, however clear and fine the weather may be, are so often visible during the appearance of a meteoric shower.

III. Papers bearing on Meteoric Astronomy.

Among the discussions of interest in this branch of observation, the probable connexion of comets and shower-meteors was first reduced nearly to a certainty by the publication of M. G. V. Schiaparelli's letters to Father Secchi, in the Bullettino Meteorologico del Collegio Romano, vol. v. Nos. 8, 10, 11, 12.

In the first letter, M. Schiaparelli communicates some observations on the August meteors of the years 1863 and 1866, made at Milan, to which (in a later letter) he applies the name of "Perseids" from the constellation which usually contains their centre of divergence. A comparison of the average horary increase in the frequency of meteors, throughout the year, from evening until daybreak, with a mathematical formula for the same variation in terms of their velocity, leads M. Schiaparelli in his opening letter to con-

* N. lat. 56° 39′, E. long. 16° 20′; opposite to the Island of Oland; not far from Carlscrona, at the southern extremity of Sweden.

clude that the real average velocity of shooting-stars in their native orbits round the sun is not far (1·447) from that of comets moving in parabolic orbits, which is greater than the earth's mean orbital velocity at the same distance from the sun in the proportion of 1·414 : 1.

In the second letter the origin of meteoric currents is discussed, of which more than fifty can be traced which have their points of radiation in the northern hemisphere, and it is shown, by their various inclinations to the ecliptic, and occasional retrograde motions, that shower-meteors rather resemble comets than planetary bodies indigenous to the solar system. Should the meteoric groups come to the sun from stellar space, then, since the August meteors have been frequently observed since the date of their first recorded appearance, in the year A.D. 830, they must compose streams of enormous length. Supposing a cosmical cloud of meteoric bodies, of the sun's size, to be moving in space transversely to its distance of, say, 20,000 times the earth's distance from the sun, with a velocity relatively to the sun of 100 yards per minute, in its approach to the sun it would pass near enough to encounter the earth, and its orbit could not then be distinguished from a parabola. It will be deformed in its course into a parabolic stream, requiring four months and a half to pass through its perihelion. At the middle of that time its *depth* at that point will be only 100 *yards*, its width twenty-three miles, and its density 400 *million times* its original density, while its two extremities will reach in both directions almost up to the orbit of the earth. A nebula subtending, under the same initial circumstances as the last, 1′ of arc would occupy more than 225 years in passing through its perihelion. Its depth would then be 36, and its width 13,800 miles. Its density would be increased in the same proportion as before; and its length along the parabolic orbit would reach, on both sides, four times the distance of Neptune from the sun. If the apparent diameter of the nebula were at first equal to that of the sun, it would occupy *seven thousand years* in passing through its perihelion. In this way meteoric currents, enduring, like that of August, for hundreds or even for thousands of years can be accounted for, whether their motion may be direct or retrograde, or at whatever obliquities they are inclined to the ecliptic.

In the third letter the origin of the November meteors is considered, and a summary is given of the new theory of shooting-stars.

From the known weight of aërolites, and the absence of any solid residues on the occurrence of even the greatest star-showers, the small mass of shooting-stars may be certainly inferred. The grains of olivine disseminated in meteorites, regarded by M. Daubrée as forming a kind of "universal scoria" (see *post*), may not impossibly compose their nuclei, whose weight, at the most, can rarely exceed a few grains. At the earth's distance from the sun a swarm of such particles a few feet apart would be broken up by the sun's attraction into a stream in which each particle would pursue an independent orbit. Even in the densest meteoric showers the meteoric bodies are some scores of miles asunder, corresponding to thousands of miles apart in the distant nebula. The sun's attraction must, accordingly, gradually deform all meteor-clouds circulating within the solar system into a continuous stream or *closed ring*; and, on this account, the November star-shower is a recent group, derived from regions beyond the solar system.

The new theory of shooting-stars is contained in the following propositions:—

"I. Matter exists in space in every degree of subdivision. Masses of the first class are isolated stars, or stars collected together in groups. Those of

the second class are clusters of small stars (or "star-dust" of Herschel), in which class are many resolvable nebulæ. The next class are smaller bodies, which become visible as comets when they approach the sun. The last class of bodies, in the smallest state of subdivision, are cosmical clouds, composed of bodies no larger than we can handle or carry on the earth.

"II. The last class of bodies may have originated from local concentrations in space, in the same way that chemical substances crystallize from their solutions. The appearance of the process of crystallization leads to the conjecture that this mode of concentration is more frequent and general than the process by which larger masses have collected. The space occupied by the cosmical clouds may, accordingly, constitute a large part of the intrastellar regions.

"III. The motions of such clouds relatively to the visible bodies of the universe are comparable to those of the fixed stars, and probably attributable to the same causes. When a cosmical cloud enters the sphere of the sun's attraction, it can only become visible to us when its orbit about the sun is an ellipse of very great excentricity.

"IV. Whatever may be the shape and size of a cosmical cloud, it can rarely enter the central parts of the solar system without being transformed into a parabolic current, which may occupy years, centuries, or thousands of years in completing its perihelion passage, in the form of a stream extremely narrow in comparison with its length. Of such streams those which the earth encounters in its annual revolution present themselves as a shower of shooting-stars diverging from a common centre of radiation.

"V. The number of meteoric currents traversing the solar system in all directions is probably very great. The extreme rarity of their materials permits them to intersect each other mutually without disturbance. They may gradually shift and change their form, like rivers which slowly change their bed. They may be interrupted, so as to become double or multiple. The November meteors are probably such a current in process of formation.

"VI. Cosmical clouds having short periods of revolution round the sun, which have been assumed to explain the appearances of shooting-stars, cannot exist permanently without violating the laws of universal gravitation.

"VII. The materials of parabolic currents, after passing through their perihelion, return to space in a state of greater dispersion than before their perihelion passage. In particular cases, as when the current meets with a planet, such great perturbations of some of the meteors may arise as to divert them from the general track, into special orbits. Such meteors may, from that time, be properly called *sporadic*.

"VIII. Shooting-stars and other like celestial bodies, which in the last century were regarded as atmospheric, which Olbers and Laplace first maintained might be projected from the moon, and which afterwards came to be regarded as planetary bodies, are in reality bodies of the same class as the fixed stars; and the name of *falling stars*, applied to them, simply expresses the real truth. They bear the same relation to comets which the planetoids between Mars and Jupiter bear to the larger planets, the smallness of the masses, in both cases, being compensated for by the greatness of their number.

"IX. Since it may certainly be assumed that shooting-stars, bolides, and aërolites only differ from each other in their comparative size, we may conclude that the substances fallen from the sky are samples of those of which the stellar universe is composed; and since in such masses no new chemical element has been discovered, hitherto unknown upon the earth, the similarity of composition of all the visible bodies of the universe, already rendered pro-

bable by researches with the spectroscope, acquires a new argument of credibility."

In the fourth letter M. Schiaparelli traces a connexion between the elements of the orbits of the "Perseids," or of the long elliptic current of meteoric bodies which produce the August meteors, and those of the orbit calculated by Oppolzer for the Comet III. 1862. The following comparion shows that the two orbits are nearly identical.

	The Perseids, 1866.	Comet III. 1862.
Perihelion passage	July 23·62	1862 Aug. 22·9
Passage through the ☋ ..	Aug. 10·75	
Longitude of perihelion ..	343° 38′	344° 41′
Longitude of ☊	138° 16	137° 27′
Inclination	64° 3′	66° 25′
Perihelion distance	0·9643	0·9626
Motion................	retrograde.	retrograde.
Period of revolution	108	113 (Stämpfer.)

In the same letter M. Schiaparelli gives the elements of the elliptic orbit of the November meteors, assuming their period to be 33·3 years.

The average real velocity of meteors found by M. Schiaparelli in his first letter is nearly confirmed, from his own observations, by Prof. Wolf, of Zürich, who, using the same formula of calculation, finds for its value 1·51, M. Schiaparelli's result from nine similar series of observations to those of Prof. Wolf being 1·477. (Les Mondes, 2nd. ser. vol. xiii. p. 24.)

The publication of M. Schiaparelli's last letter was anticipated by Father Secchi in his description of the November shower of meteors in 1866 (see Les Mondes, 2nd ser. vol. xii. p. 647, 20th Dec. 1866), the fourth letter only appearing in the monthly Number of the Bullettino Meteorologico for the 31st of December, 1866, and the former letters in the Numbers for the previous months.

At a meeting of the Société Scientifique de France on the 14th of January, 1867, and in a subsequent paper in the 'Comptes Rendus' (January 21st), M. Le Verrier announced the introduction of the November meteoric group into its present orbit to have been probably effected by the planet Uranus; within a short distance of whose orbit the aphelion of the long elliptic orbit of the meteors, with a period of 33·25 years, must be situated; and the meteors themselves must nearly have encountered the planet in the year A.D. 126. Before that time their orbit may have been either within or beyond the regions of the planetary orbits. M. Le Verrier adds that "there is nothing to oblige us to suppose that the group did not originally belong to the solar system." In later letters * M. Schiaparelli suggests that either of the two planets Saturn or Jupiter, rather than Uranus (on account of the comparatively small sphere of attraction of the latter planet being more calculated to disperse than to deflect a group of meteoroids from a very long elliptic into an elliptic orbit of the short period of 33·25 years), may have been instrumental in bringing the November meteors into their present close proximity to the earth. It should, however, be observed that the meteoric group does not pass so near the orbits, nor remain so long in the neighbourhood of either of those planets, as it approaches to the planet Uranus, partly in consequence of the inclination of the orbit to the plane of the ecliptic, and partly because of the more rapid motion of the meteors near the sun than at the point of their more distant appulse with the latter planet †.

* Les Mondes, 2nd ser. vol. xiii. p. 251.

† Sir J. Herschel's 'Outlines of Astronomy,' 9th Edition (1868), Note to Art. 902.

A remarkable discovery was made shortly after these announcements, on the publication (Astronomische Nachrichten, No. 1624) by Oppolzer, of the corrected elements of the Comet I. 1866, that the orbit of the comet coincides almost perfectly with the long elliptic orbit of the November meteors having a period of 33·25 years. The note of Mr. Peters, dated January the 29th, is in the same No. 1624 of the 'Astronomische Nachrichten;' and those of Oppolzer and Schiaparelli, announcing the same discovery, are in an immediately following Number (1626) of the same Journal. In 'Les Mondes' for the 21st of February (2nd ser. vol. xiii. p. 287), and in Father Secchi's Bullettino Meteorologico for the last day of February 1867 (vol. vi. No. 2), there appeared additional letters of M. Schiaparelli on the subject of this second newly found connexion between comets and meteoric showers.

In that addressed to 'Les Mondes' *, a convincing comparison of the elements of the two orbits is thus given by M. Schiaparelli, viz.:—

Elements of the Orbits of the November Meteors, and of Comet I.

	(1866.)	1866.
Passage through the ☊	Nov. 13·575	
,, ,, perihelion..	Nov. 10·092	Jan. 11·160
Long. of the perihelion........	56° 25′·9	60° 28′·0
,, ,, ☊	231° 28′·2	231° 26′·1
Inclination	17° 44′·5	17° 18′·1
Perihelion distance	0·9873	0·9765
Excentricity	0·9046	0·9054
Semiaxis major..............	10·340	10·324
Periodic time of revolution	33·250 yrs.	33·176 yrs.
Motion	retrograde.	retrograde.

To establish the reality of this resemblance, it was desirable to place beyond a doubt the assumed correctness of the long elliptic orbit of the November meteors with a periodic time of 33·25 years. The researches of Professor Adams, with this object in view, which appeared in the 'Monthly Notices of the Royal Astronomical Society' for March 1867, are thus noticed by Prof. H. A. Newton †, by whom the importance of this inquiry was first pointed out, in a paper noticed in these Reports (for 1864, p. 96) on "the original accounts of the displays in former times of the November Star-showers, and the probable orbit of the group of bodies around the Sun."

"It was shown some time ago (this Journal, II. xxxviii. 57) that the periodic time of the November meteors must be one of five accurately determined periods. These five periods were 180·0 days, 185·4 days, 354·6 days, 376·6 days, and 33·25 years. The longitude of the node was also shown to increase with respect to the ecliptic 1′·711 in a year, which is equivalent to a procession with respect to the fixed stars of 29′ in a cycle of 33·25 years. It was also suggested that by computing the secular motion of the node for each one of the five possible orbits, and by comparing it with the observed motion, we have an apparently simple means of deciding which of the five orbits is the true one.

"Soon after the remarkable display of the meteors in November of last year ‡, Prof. Adams undertook the examination of this question. Taking first the orbit corresponding to a periodic time of 354·6 days, he found that the action of Jupiter produces an annual increase of the longitude of the node equal to 6″, and that of Venus an annual increase equal to 5″. The action

* Dated at Milan, the 2nd of February.

† American Journal of Science, 2nd ser. vol. xliv. p. 127.

[‡ 1866, Nov. 13–14.]

of the earth was not so easily computed, owing to the intersection of the two orbits. An approximate solution applicable to this case showed, however, an annual increase of the longitude of the node of about 10″ due to this cause. The whole computed procession of the node was therefore about 21″ a year, or 12′ in the cycle of 33·25 years.

"The periodic time 376·6 days gives a result not widely different from the above, while in the two smaller orbits there would be a much smaller motion. Hence these four orbits, out of the five possible ones, are incompatible with the observed motion of the node.

"Computing, then, the effect of the perturbing action of the planets upon the group, supposing it to have a periodic time of 33·25 years, Prof. Adams found that Jupiter increases the longitude of the node 20′ in one revolution, that Saturn increases it 7′, and Uranus increases it 1′; the other planets produce hardly any sensible effect; so that the entire calculated increase of the longitude of the node in the period of 33·25 years is about 28′. The observed increase during the same time is 29′. This remarkable accordance between the results of theory and observation appears to leave no doubt as to the correctness of the period of 33·25 years."

Supposing a meteor-current to be the regular concomitant of a comet, whose presence on the same orbit with the comet can only be perceived at a point of encounter with the earth, a list of those comets whose orbits most nearly approach the orbit of the earth, was prepared by Dr. Weiss, of Vienna, (Astron. Nachrichten, No. 1632). The distance of such a comet from the sun in the ecliptic (r), at the place of its ascending (☊) or descending node (☋), is nearly equal to the earth's distance (supposed unity) from the sun at the instant of its nodal passage through the plane of the comet's orbit. The following list contains the data thus obtained by Dr. Weiss.

Date of Shower.	Nodal passage.	Comet.	Node.	r.	Remarks.
Jan. 1– 4.	Jan. 3.	II. 1792	☋	0·983	
1– 4.	4.	IV. 1860	☊	0·985	
18–20.	18.	1672	☋	1·046	
18–20.	20.	I. 1840	☊	0·948	
28.	26.	1092	☊	0·977	
Feb. 13–14.	Feb. 13.	IV. 1854	☋	0·973	
13–14.	14.	IV. 1858	☋	0·973	
Mar. 5–10.	Mar. 8.	III. 1854	☊	1·025	
5–10.	8.	1490	☊	0·960	
5–10.	13.	1683	☊	1·047	
16–20.	16.	1763	☋	1·020	
16–20.	16.	IV. 1862	☋	0·982	
Apr. 16–25.	Apr. 16.	I. 1830	☊	0·923	
16–25.	17.	837	☊	1·026	Very uncertain orbit.
16–25.	20.	I. 1861	☋	1·003	P = 415 years.
16–25.	22.	II. 1748	☋	0·886	
16–25.	24.	III. 1790	☋	1·052	
May 18–26.	—	—	—	—	
July 27–30.	July 27.	II. 1737	☋	9·995	
Aug. 7–13.	Aug. 9.	II. 1852	☊	1·025	
7–13.	9.	III. 1862	☋	1·019	P = 113 years.
16–20.	19.	II. 1862	☊	1·039	

TABLE (*continued*).

Date of Shower.	Nodal passage.	Comet.	Node.	*r*.	Remarks.
Sept. 1– 5.	—	—	—	—	
16–25.	Sept. 16.	I. 1790	☊	1·058	Very uncertain orbit.
16–25.	18.	1763	☊	0·974	
Oct. 16–26.	Oct. 16.	IV. 1864	☊	1·045	
16–26.	18.	1779	☊	0·972	
16–26.	20.	1739	☊	1·073	
16–26.	21.	1097	☊	0·944	
16–26.	24.	1366	☊	1·048	
Nov. 14.	Nov. 13.	I. 1866	☊	—	P = 33·18 years.
28.	26.	I. 1766	☊	0·853	
28.	28.	Biela	☊	1·004	P = 6·6 years.
28.	29.	I. 1743	☊	0·881	
Dec. 6–13.	Dec. 9.	IV. 1819	☊	0·815	P = 4·8 years.

On calculating, in the next place, the point of radiation which a meteoric shower would appear to have, if it moved in the same orbit as Biela's comet, Prof. D'Arrest, of Copenhagen, found (Astron. Nachrichten, No. 1633) that it agrees very closely with that of the December star-shower, whose maximum still occurs on the 12th of December, but of which the first symptoms can be distinguished as early as the 29th of November. The earth now crosses the orbit of Biela's comet on the latter, but in the last century on the former date. The great shower of meteors seen by Brandes on the night of the 6th of December, 1798, may very possibly have been connected with the periodical reappearance of this comet in the following year, which must have passed close to the same point of the earth's orbit in the month of May 1799.

From the elements of Comet I. 1861, Dr. Galle, of Breslau (Astron. Nachrichten, No. 1635) determined the radiant-point which the cometary particles would appear to have if, on the date of the earth's passage near its orbit (the 20th of April), they were to encounter the earth as meteors, and found for its apparent place long. 267°·2, N. lat. 57°·0, about seven degrees from the place (in R. A. 277°·5, N. Decl. 34°·6) observed by Mr. Herschel in 1864, or (in R. A. 278°·2, N. Decl. 34°·5) by Prof. Karlinski * at Cracow, in 1867, as the position of the radiant-point of the great star-shower of the 20th of April, already noted by Herrick, in 1839, as having its point of radiation near α Lyræ. Assuming that the meteors, like the comet, have a periodic time of 415 years, Dr. Galle gives the following very similar elements of their orbits—

	Meteors of April 20.	Comet I. 1861.
Longitude of perihelion	236°	243°
Longitude of ☊	30°	30°
Inclination	89°	80°
Perihelion distance	0·9550	0·9204
Excentricity	0·9828	0·9835
Semiaxis major	55·72	55·72
Periodic time	415 years.	415 years.
Motion	direct.	direct.

* Dr. Galle, in 'Astronomische Nachrichten.' See Astronomical Register for July 1867, vol. v. p. 160.

—as indicating very probably a physical connexion between this comet and the current of the April meteors.

Two recently discovered periodical comets being thus pretty certainly shown to be connected with the material currents which give rise to the August and November meteors, and two others being very probably identified with the meteor-currents of April and December, the community of origin (frequently believed by writers of late years to exist) between shooting-stars and comets appears to be conclusively established.

To assist the observation of luminous meteors, a first catalogue of shooting-stars observed in Italy during the years 1866–67 was published at Milan in July of last year, by M. Schiaparelli. The principal object being to ascertain the positions of their radiant-points, certain nights of the year were named beforehand by M. Schiaparelli for simultaneous observations, in order to multiply, as far as possible, the number of separate meteors recorded by observers cooperating to register their tracks at distant stations on a single night. The first portion of the catalogue consists, almost entirely, of 572 observations of meteors, made by M. G. Zezioli, assistant director of the telegraph-office at Bergamo, between the 26th of April and the 10th of July, 1867.

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* Now succeeded by M. Chapelas.

*List of Radiant-Points of Meteoric Showers in the Northern Hemisphere**. By R. P. Greg.

Epochs, in their order of commencement.	Greg (G); (H) Herschel; (Z) Zezioli. Distinctive Names.	Approximate place of Radiant, by Fixed Stars of Bode's Constellations.	True place (1860). R.A.	True place (1860). N.P.D.	Remarks. (N.B. These observations are to be regarded as only provisional.)
Dec. 20–Jan. 30 ...	$A_{1,2}$	δ Cassiopeiæ	21°	34°	Probably a 12-year period; *max.* 1848–52. Radiant requires investigation.
Dec. 20–Feb. 6	AG_1	α Tauri	68	70	Radiant elongated, diffuse. *Max.* 1861, Dec. 24.
Dec. 20–Feb. 26 ...	NG	Polaris	10	5	$N_{1,2,3,4}$ of Heis. Probably extends to γ Cephei.
Jan. 1–25	MG_1	Canes Venatici	172	59	Twin or double radiant; $M_{2,3}$ of Heis. *Max.* 1864, Jan. 24.
			187	50	
Jan. 2–3...............	$K_{1,3}$	υ Herculis	238	49	U. S. America, 1863 } Radiant region small and well defined; circumpolar.
		c Quadrantis	234	39	Hawkhurst, 1864
			225	35	Manchester, 1864
Jan. 2–Feb. 9	$M_{1,2}$	n Lyncis	128	50	(?$=M_3$.) *Max.* Jan. 25–31. Gives occasional large meteors.
Jan. 3–Mar. 16......	S_1, SG_1	α Hydræ	139	98	Radiant diffuse and elongated. *Max.* 1850–51 and 1863, Feb. 10–15; probably advancing with the time; and also connected together by intermediate meteors, whitish.
Feb. 10–Apr. 2	$S_{2,3}$	β Leonis	175	80	
			151	100	
Jan. 21–Mar. 20 (?)	$M_{1,5}$	σ Ursæ Majoris	145	19	Radiant rather elongated and diffuse; occasionally gives large meteors; perhaps connected with M_6. Requires further examination.
			140	19	
Jan. 28–29............	QZ	γ Coronæ	233	64	Described by Schiaparelli and Zezioli; 150 meteors seen at Bergamo, 1868, Jan. 29, 4^h–6^h A.M.
Feb. 4–26	M_3	Leo Minor	153	55	(?$=M_{1,2}$); radiant advancing with the time. *Max.* Feb. 14. Meteors small and swift.
Feb. 9–17 (?).........	$A_{3,4}$	Hædulæ	73	50	Radiant well defined and limited; commencement of AZ.
Mar. 1–15	A_5 (?)	α Persei	50	43	A_5 of Heis probably confirmed; from Italian observations.
Mar. 3–25	SZ_1	δ, ε Ophiuchi	247	93	Possibly commencement of SG_2 or of SZ_2. Meteors quick.
Mar. 3–April 2	N_5	ι Cassiopeiæ	38	23	Radiant well defined; continues probably into April.
Mar. 3–April 30 ...	$M_{6,7}$	δ Ursæ Majoris	180	30	Radiant advances with the time, and also double; all one shower (?). Meteors move slowly; endures 10 weeks.
Apr. 25–May 25 ...	$M_{7,8}$	η Ursæ Majoris	202	38	
Mar. 5–17	S_4	γ Virginis	190	89	Probably connected with $S_{5,6}$; meteors white, rather swift.

* The radiant-points $S_{1,2,3}$, SG_2, OZ, (H), and U, included in this list, properly belong to the southern hemisphere. See Heis and Neumayer's list of southern radiants at p. 405 of this Report.

List of Radiant-Points of Meteoric Showers in the Northern Hemisphere (continued).

Epochs, in their order of commencement.	Greg (G); (H) Herschel; (Z) Zezioli. Distinctive Names.	Approximate place of Radiant, by Fixed Stars of Bode's Constellations.	True place (1860). R.A.	True place (1860). N.P.D.	Remarks. (N.B. These observations are to be regarded as only provisional.)
Mar. 9–27	AZ, ($A_{3,4}$ continued)	Telescopium	110°	57°	On the nights of March 11, 20, 21, 27, 1868, a series of radiants were noticed by Zezioli about Castor, Telescopium, and Capella, all giving small, rapid meteors.
			73	45	
Mar. 11–Apr. 23 ...	DG	γ Draconis	270	35	Probably commencement of DG_2.
Mar. 12–Apr. 30 ...	MG_2	β Bootis	223	50	Radiant perhaps extends to θ Coronæ. *Max.* 1851–61?
Mar. 15–Apr. 20 ...	WZ	γ Cygni	305	53	An A.M. (morning) shower.
Mar. 15 (?)–Apr. 23	QH_1	Cerberus	268	65	A.M. showers; probably C of Heis. QH_1 small and swift, long paths, trained; QH_2 slower, bright white, trained; or yellowish, no trains. *Max.* April 19–21, 1803 and 1839, U. S. America. Hawkhurst, 1864.
Mar. 19–Apr. 21 ...	QH_2	α Lyræ	277	55	
			278	56	Cracow, 1867; described by Drs. Galle and Karlinski.
Mar. 20–May 29 ...	SG_2	β, δ Libræ	224	101	? Commences at σ Virginis; meteors large, not trained. At δ, ε Ophiuchi in 1868.
Mar. 22–Apr. 23 ...	MZ	θ Ursæ Majoris	146	44	M_4 of Heis; small rapid meteors with short paths.
Mar. 25–Apr. 20 ...	OZ	Scutum Sobieski	290	100	More observations required.
Mar. 25–Apr. 24 ...	MGZ	Canes Venatici	198	58	
Mar. 27–May 15 ...	SZ_2	α Serpentis	230	85	Possibly continuation of SZ_1; also observed by G. and H. in 1867–68.
Apr. 2–May 4	$S_{5,6}$	δ, ε Virginis	189	85	Radiant probably commences at σ Virginis. In 1868 at τ Virginis?
			200	77	
Apr. 10–May 4......	N_8	Polaris	70	5	Radiant well defined.
Apr. 19–20	M_3,Z	γ Leonis	152	68	Seven meteors from this radiant, 1868, April 19–20, at Bergamo.
Apr. 23 (?)–May 31.	DG_2	β, γ Draconis	270	35	Radiant well defined. *Min.* 1863–65? Meteors quick, not bright.
Apr. 23–June 4......	Q_1, (Q_2)	β Herculis	245	69	Radiant double, advancing with the time. *Max.* 1850; 12- or 13-year periods? Perhaps commences 10th April, or earlier.
			(235	60)	
Apr 27–June 30 ...	$N_{9,10}$	κ Cephei	305	9	Radiant definite. *Max.* June 13–17, 1849–52?
Apr. 29–May 15 ...	Y	i, k Leonis	160	75	Elongated radiant?
			167	70	
Apr. 29–June 12 ...	MG_4	m Lyncis	123	50	A.M. (morning) shower.
May 6–June 20......	W	Lyra	280	61	Radiant elongated. *Max.* 1850? Gives large meteors, no trains; not a continuation of QH_2.
May 14–June 20 ...	WG	Delphinus	312	69	Elongated radiant. *Max.* 1848–50?
May 24–June 3......	S_8	ξ Virginis	198	86	Possibly a continuation of $S_{5,6}$.
May 24–June 30 ...	(Q_1), Q_2	Corona Borealis	(245	69)	$=Q_1$ continued. *Max.* June 16–26; *Min.* 1856–57.
			235	60	
June 1–29	MG_3	β Ursæ Majoris	168	35	Radiant diffuse. NB. more observations needed; aërolitic epoch.
June 1–Aug. 17......	QG	β, α Aquilæ	294	87	Radiant well defined; $\Xi_{1,2}$ of Neumayer and Heis. *Max.* 1867.

June 11–July 11 ...	B_1	α Cephei	325	30	B_1 or B_2 of Heis.
June 29–Aug. 24 ...	T_1	α Pegasi	338	77	Radiant slightly elongated.
July 1–July 11	MG_5	ξ Ursæ Majoris	210	35	From Zezioli's Italian observations.
July 1–July 11	Q_1	α Böotis	210	70	From Zezioli's Italian observations. [Σ_1 of Heis and Neumayer.
July 2–Aug. 8	(H)	Fomalhaut	338	118	Radiant elongated? *Max.* 1840? and 1865, July 28. Commencement of Y_1, or
July 2–Aug. 16......	B_3	o Draconis	280	35	? Connected with B_4 or B_5; occasional large meteors. *Max.* July 8–14.
July 4–11	A_9	ϕ, θ Andromedæ	7	48	A_9 of Heis? From Zezioli's observations.
July 4–Aug. 22......	BG	ζ Cygni	315	59	} *Max.* July 30.
July 10–Aug. 20 ...	B_4	α Cygni	307	40	} Perhaps connected; if so, double radiant and contemporaneous.
July 4–Sept. 12......	Q_3	β Herculis	246	69	Radiant diffuse.
July 7–Aug. 4	N_{11}	ψ Cassiopeiæ	15	20	Radiant rather elongated and diffuse. *Max.* July 29? *Min.* 1863–64?
July 28–Aug. 16 ...	A_0 or A_{10}	*k* Persei (α Persei to ϵ Cassiopeiæ)	44 (50 (25	34 40) 25)	*Max.* Aug. 9–11; radiant of the "Perseids;" extends to δ, ϵ Cassiopeiæ? *Min.* years 1838, 1846, 1854, 1862.
July 28–Sept. 10 ...	$N_{12,\ 13}$	Polaris	0	0	Radiant well defined and fixed.
July 28–Sept. 29 ...	$R_{1,\ 2}$	δ Andromedæ	5 11	54 61	} Radiant double or elongated. *Max.* 1862–64. } P_1 of Heis?
July 29–Sept. 6......	V	α, δ Ursæ Majoris	172	30	From English, German, and Italian observations.
Aug. 2–Sept. 25 ...	B_5	π Lyræ	285	46	Perhaps connected with B_4 or B_3.
Aug. 7–Sept. 30 ...	E	*c* Lacertæ	335	38	Individual meteors not generally trained; occasionally large ones.
Aug. 22–Nov. 5......	$T_{2,\ 3,\ 4}$	γ Pegasi	0	76	Perhaps connected with T_1, advancing with the time. Σ_2 of Heis and Neumayer.
Sept. 6–Nov. 23 ...	U	θ Ceti	17	100	Radiant elongated. *Max.* Sept. 27, 1864, Hawkhurst. Meteors move slowly.
Sept. 12–Nov. 25 ...	$A_{11,\ 15}$	α, δ Cassiopeiæ	10 25	36 30	} Meteors white, not trained, occasionally large. [Σ_3 of Heis and Neumayer. } Perhaps connected with A_{16}; radiant extends to η Persei.
Sept. 17–Nov. 24 ...	$F_{1,\ 2}$	α, β, δ Aurigæ	83 92	40 35	} Radiant double or elongated, advancing with the time. *Max.* 1863–64? *Min.* Oct. 12–18. Meteors bright, rapid, trained, yellowish.
Sept. 19–Oct. 20 ...	N_{14}	Polaris	10	2	Radiant definite; perhaps continuation of $N_{12,\ 13}$. Meteors swift.
Oct. 3–20	LG	*p* Lyncis	143	48	Radiant slightly elongated.
Oct. 14–Dec. 13 ...	R_3	Musca	41	66	Radiant elongated. *Max.* 1864?
Oct. 17–Nov. 13 (?)	O	ν Orionis	90	75	*Max.* 1864–67, Oct. 18–20. Radiant very well marked at ν Orionis.
Oct. 18–29............	BG_6	π Lyræ	279 260	43 45	} More observations wanted; radiant perhaps extends to β, η Draconis.
Oct. 25–Nov. 21 ...	RG	α Tauri	64	72	
Oct. 31–Dec. 12 ...	L(H)	ζ Hydræ	134	84	*Max.* 1863–65? Meteors swift, slightly phosphorescent.
Nov. 4–Dec. 19......	KG	λ Draconis	160	19	Radiant elongated.
Nov. 13–15	L_0	*x* Leonis	149	67	A.M. shower. Cycle 33¼ years. Meteors phosphorescent, trained, occasionally
Nov. 23–Dec. 9......	DG_3	o Draconis	290	35	[large. The "Leonids;" *max.* 1799, 1833, 1866–67.
Nov. 23–Dec. 18 ...	A_{16}	B Camelopardi	45	30	Radiant elongated. *Max.* 1848–52.
Nov. 26–Dec. 30 ...	G	θ Geminorum	100	57	*Max.* 1862–63, Dec. 9–13. Aërolitic epoch. Meteors of various sizes, rather quick, sometimes trained, bluish white.
Nov. 26–Dec. 30 (?).	Ga	Capella	74	45	? Pseudo-radiant of G_1, $A_{1,\ 2,\ 16}$.

Mr. Greg having undertaken the projection of M. Zezioli's observations on the appropriate gnomonic star-charts of the British Association, several new radiants were discovered, and the positions and durations of old ones were found to be confirmed, and of others to require only inconsiderable corrections, of which the shortness of the nights and the consequent scarcity of meteor-observations in England during the summer months had hitherto prevented the determination with precision.

The preceding list of radiant-points of the northern hemisphere, corrected and enlarged, by means of the additional observations, from that formerly printed in these Reports (for 1864, p. 99), is extracted from a new edition of the Atlas of plane-perspective Meteor-charts (for 1868) of the Luminous-Meteor Committee of the British Association, which will, this year, be offered for sale by members of the Committee, at the price of lithographing copies of the Atlas, or of single charts, according to the wants and occasional requirements of observers *.

Besides the observations of shooting-stars now mentioned, which M. Schiaparelli has lately published in the Milan 'Ephemeris of Astronomy,' three memoirs on shooting-stars observed in Piedmont during the August and November star-showers of 1866–67 †, by Father F. Denza, Director of the Observatory at Moncalieri, near Turin, contain useful abstracts of observations, and notices of recent papers on meteoric astronomy, together with instructions for future systematic observations of meteors at various stations in Piedmont.

The following list of radiant-points in the southern hemisphere (p. 405), compiled by Professor Heis from nearly 2000 observations of shooting-stars made by Dr. Neumayer at the Flagstaff Observatory at Melbourne, is taken from the Table at the end of the third of Father Denza's memoirs ‡. No great star-shower was recorded by Dr. Neumayer as having been seen at Melbourne during the period of five years (1858–63) in which the observations were carried on.

Professor Heis regards the observations discussed and reduced in this list as of peculiar importance, on account of the care with which the apparent paths and the apparent size, colour, duration, &c. of the meteors were recorded. Thirty-five new radiant-points are developed in the southern hemisphere, and the positions of four previously established radiant-points ($S_{1, 2, 4, 6}$) are corroborated, by the observations, and are included in the southern list. Some of the radiant groups sufficiently resemble those obtained by Professor Heis as the result of his own indefatigable labours in the northern hemisphere, or those assigned for the same hemisphere by Mr. Greg, so as to make in these cases a further investigation of especial interest.

* The sale of the maps, at a rather higher price (owing to the expense of drawing three new charts and relithographing the old plates for the new edition of the Atlas) than would make them accessible to the majority of observers, was this year begun at Norwich, by the agents (Messrs. Taylor and Francis) for the sale of the volumes of these Reports. Four copies of the Atlas were thus sold to members of the Association at Norwich; and the remaining sixteen copies struck off for the occasion of the Meeting, to represent this edition of the Atlas, are kept on hand for the use of British and foreign observers, for whom the price is reduced to 25s. for a single copy. The Committee are unable to offer copies to observers at a lower price, on account of the large number of copies of the Meteor-Atlas which were last year sent, gratis, to the foregoing destinations (see the list on p. 400).

† Le Stelle Cadenti osservate in Piemonte. Del P. Francesco Denza, B., Memorie 1, 2, 3. Torino, 1867–68.

‡ The original memoir of Drs. Heis and Neumayer, "On Meteors in the Southern Hemisphere" (4to, Mannheim, 1867), is extracted from Dr. G. Neumayer's "Discussion of the Meteorological and Magnetical Observations made at the Flagstaff Observatory at Melbourne."

List of Radiant-points of Meteoric Showers in the Southern Hemisphere. By Drs. Heis and Neumayer.

Ref. No.	Month.	Constellation.	Position. R. A.	Position. N. Decl.	Greek or Roman literal designations.	Remarks.
1.	January ...	Canis Major	105°	−27°	Γ_2.	
2.	,,	Argo Navis	145	−40	Δ_2.	
3.	February	Puppis Argo	105	−45	Γ_3.	
4.	,,	Centaurus	174	−52	Δ_3.	
5.	,,	Leo Major	174	+16	S_1.	
6.	March ...	Argo Navis	125	−38	Γ_4.	
7.	,,	Hydra	174	−30	Δ_4.	
8.	,,	Centaurus	192	−38	H_1 *	*Not=(H) of
9.	,,	Virgo	181	+ 6	S_2.	Greg's list;
10.	April	Centaurus	194	−30	H_2 *.	see below,
11.	,,	Telescopium	280	−38	Λ_1.	No. 27.
12.	,,	Argo.................	126	−42	Γ_4.	
13.	,,	Coma Berenices ...	185	+22	S_4.	
14.	May	Lupus	212	−49	H_3 *.	
15.	,,	Norma	248	−46	Λ_2.	
16.	,,	Virgo	202	+ 9	S_6.	
17.	June ...	Scorpius	253	−37	Λ_3.	
18.	,,	Sagittarius	269	−11	O_1.	
19.	,,	Capricornus.........	305	− 7	Ξ_1	=WG (?) or
20.	July	Corvus	284	−40	Λ_4.	QG of G.'s
21.	,,	Ophiuchus	258	−20	O_2.	list.
22.	,,	Phœnix	354	−46	Π.	
23.	,,	Octans	50	−85	P.	
24.	,,	Delphinus	305	+ 5	Ξ_2	=QG.
25.	August ...	Scorpius	250	−35	Λ_5.	
26.	,,	Aquarius	337	−10	Σ_1.	
27.	,,	Grus..................	325	−38	Υ_1	=(H) of G.'s l.
28.	September	Aquarius	346	− 3	Σ_2	$=T_{2, 3, 4}$ of
29.	,,	Sagittarius	305	−36	Υ_2.	Heis and
30.	,,	Piscis Austrinus ...	340	−30	Φ.	Greg.
31.	October ...	Piscis Austrinus ...	10	−35	X_1.	
32.	,,	Pisces	347	−11	Σ_3	=U of Heis
33.	,,	Eridanus	50	− 4	Ψ.	and Greg.
34.	,,	Indus	307	−47	Υ_3.	
35.	November	Cetus	22	−35	X_2.	
36.	,,	Columba	90	−34	Ω_1.	
37.	December	Columba	85	−37	Ω_2.	
38.	,,	Argo..................	115	−38	Γ_1.	
39.	,,	Antlia Pneumatica	148	−34	Δ_1.	

The radiants $\Xi_{1, 2}$ in the southern list correspond very nearly in time and place with the radiants WG, QG of the northern hemisphere; and the new group of southern radiants, $\Sigma_{1, 2, 3}$, closely adjoins the group $T_{1, 2, 3, 4}$ and the radiant U of the older list, making it to appear probable that these radiant-points are common to both hemispheres of the globe.

	$\alpha=$	$\delta=$			$\alpha=$	$\delta=$
Ξ_1, June, in Capricornus ...	305°	− 7°	WG,	May 14–June 20, in Delphinus	312°	+21°
Ξ_2, July, in Delphinus	305	+ 5	QG,	June 1–Aug. 17, in Aquila ...	294	+ 3
Υ_1, August, in Grus	325	−38	(H),	July 2–Aug. 8, in Pisc. Austr.	338	−28
Σ_1, August, in Aquarius ...	337	−10	$T_{1, 2}$,	June 20–Aug. 24, in Pegasus...	338	+13
Σ_2, September, in Aquarius	346	− 3	$T_{3, 4}$,	Aug. 22–Nov. 5, in Pegasus ...	0	+14
Σ_3, October, in Pisces.........	347	−11	U,	Sept. 6–Nov. 23, in Cetus	17	−10

The radiant (H) determined independently in 1865 (see Report, pp. 104, 123) is

well corroborated by two radiant-points in Prof. Heis's list, Y_1 and Σ_1, being almost intermediate in position, and a little earlier in date of its appearance, with respect to each of them. It may, accordingly, be regarded as the commencement of either of those showers, or even as the starting-point of a whole series of showers Y, Σ, T, U which have their centres of divergence, in autumn, in the vicinity of the equator. The new radiant-points X_1, $_2$ (the latter in the constellation Cetus), in October and November, are also not impossibly allied appearances, and the latter, perhaps, a continuation of the last radiant of the group U, near θ Ceti.

Among the radiant-points in the new list which (like that of the November meteors in the northern hemisphere) lie closest to the tangential apex of the earth's way, two especially may be noticed in the southern hemisphere, viz.

	$\alpha=$	$\delta=$	Position of tangential point. $\alpha=$	$\delta=$	
Λ_1, April, in Telescopium	280°	−38°	296°	−21°	For the middle of the month.
Δ_1, December, in Antlia Pneum....	148	−34	175	+ 2	

The central positions of the radiant groups in the southern hemisphere for the different months shows a total number of 15 separate groups; and of the meteors mapped about 627 appear to be sensibly conformable to them. The following is a brief classification of the list:—

No.	Designation of group.	Central position. $\alpha=$	$\delta=$	Constellation.	Months.	Number of meteors mapped.
1.	Γ	115	−34	Argo Navis ...	Dec., Jan., Feb., March, April	100
2.	Δ	162	−40	Antlia Pneum.	Dec., Jan., Feb., March	73
3.	H	206	−37	Centaurus	March, April, May	83
4.	Λ	266	−41	Telescopium ...	April, May, June, July, Aug.	61
5.	Ξ	305	− 1	Aquila	June, July	27
6.	O	264	−17	Ophiuchus.....	June, July	26
7.	Π	354	−46	Phœnix	July	30
8.	P	50	−85	Octans	July	13
9.	Σ	342	− 8	Aquarius	August, September, October	43
10.	Y	315	−40	Microscopium	August, September, October	59
11.	Φ	340	−30	Piscis Austr. ...	September	14
12.	X	16	−35	Cetus	October, November	24
13.	Ψ	50	− 4	Eridanus	October	13
14.	Ω	86	−35	Columba	November, December	33
15.	S	188	+13	Virgo	February, March, April, May	28
						Total 627

Of these groups the greater number are either near the equator or else near the parallel of the declination of the zenith at Melbourne, about 38° S. declination. Only one radiant-point, viz. P, in July, is found in the vicinity of the South Pole of the heavens; while, on the contrary, in the northern hemisphere a large proportion of the radiant-points visible throughout the year are either situated very near to the North Pole of the heavens, or are circumpolar. Were a series of meteor-observations in the southern hemisphere to be continued over as great a number of years as that which has been carried out in the northern hemisphere, it is probable that the number of radiant-points discovered would not only be increased, but also be found distributed more uniformly over the sky than those which have now been assigned to it, and whose positions are indicated in the present list.

No star-showers were observed at Melbourne during the epochs (for the northern hemisphere) of the 2nd of January, 19th–21st of April, 18th of October, 13th-14th of November, and 3rd–13th of December, during the five-year period of the observations, from 1858 to 1862. The months of June, July, and August are regarded by Dr. Neumayer as particularly rich, with respect to the hourly frequency of meteors. Many fine meteors were seen on board of the frigate 'Novara,' on the voyage from Funchal to Rio Janeiro, between the 27th of July and the 2nd of August, 1857. An unusual number of meteors was also seen at Melbourne towards the end of February and between the 8th and 17th of May in the year 1859. A notable number of shooting-stars and fireballs was seen at Victoria on the night of June 12–13, 1861. A great number were also seen by M. Poey at Havannah, on the nights of the 27th and 28th of July 1862. Maxima of frequency of shooting-stars, in various years of the interval from 1858 to 1862, were observed at Melbourne on the following dates:—Jan. 28–Feb. 2, Mar. 12–15, May 8–17, June 3–14, July 27–Aug. 2, Aug. 5–7, Oct. 25, Dec. 6, 12, 18, and 25.

The average hourly frequency, for the different months of the year, given in the memoir, differs in a very small degree from the results of the Melbourne observations as formerly stated in these Reports*.

Particular accounts of several large meteors recorded in the southern continent of Australia are included in the memoir, which have either been described in these Reports†, or for which the original memoir must be consulted for special details of their description.

"Notes and Reflections on the Astronomical Theory of Falling Stars," by G. V. Schiaparelli‡.—In continuation of his former letters to Father Secchi on the orbits and probable origin of luminous meteors, Professor Schiaparelli last year resumed the subject, in a memoir read before the Florentine Academy of Sciences, containing additional notes and mathematical considerations of importance on the astronomical theory of shooting-stars.

According to the best received hypothesis which existed before the discovery of their connexion with comets, the sun was regarded as surrounded by a series of meteoric rings, one of which, that of the November meteors§, returning once in a cycle of about 33·25 years, contains a principal group of meteors collected in one portion of its circumference, the remaining portions of the annulus being either nearly free from or totally devoid of meteors. Star-showers of annual occurrence like that of the 10th of August, present the phenomenon of a nearly continuous stream of meteors, varying only slightly in density in its different parts; while those which appear, at uncertain intervals of years, on the 2nd of January and 20th of April, must form a discontinuous stream of meteoric bodies, consisting of meteor groups irregularly distributed along its length, and separated from each other by intervening gaps. Finally, those isolated appearances described in catalogues as great star-showers of former times, which are not known to have returned, and the modern star-showers of the 12th of December, including, perhaps, among its appearances the great display of meteors observed by Brandes on

* Report for 1865, p. 132.

† See Report for 1866, p. 127.

‡ Memorie della Società Italiana delle Scienze, 3rd ser. vol. i. pt. 1. 4to. Florence, 1867.

§ The term "Leonids," if applied to this shower as radiating from some point in the constellation Leo, may, not improperly, be used to distinguish it from other meteors appearing simultaneously with it, as Professor Schiaparelli has applied the term "Perseids" to indicate the meteors of the 10th of August which radiate from some point in the constellation Perseus. Mme. Scarpellini has employed the word "uranatmi" (sidereal exhalations) to designate shower-meteors generally.

the 6th of December 1798, of which no former record appears to be preserved, must rather have been temporarily, and, in the latter case, recently introduced into the solar system from without.

The real form and extent, and the mode of the production, of meteoric rings would thus remain uncertain, if the recent discovery of their affinity with periodic comets had not to some extent revealed their history, and removed, at length, one chief obscurity from the theory of meteor rings—that is to say, their frequent retrograde motions, and great obliquities to the ecliptic, of which the nebular hypothesis of Laplace, when it is attempted to be applied to explain their origin, can give no account.

The two principal meteoric showers, of August and November, and probably also those of April and December, having been recently identified in their orbits with the orbits of certain periodic comets, one of which performs its revolution, with a periodic time of upwards of 400 years, in an orbit extending, at its greatest distance, twice as far as the furthest planet, Neptune, from the sun, the community of origin of comets and shower-meteors, at first suspected, now appears to be finally established. It is stated in the first chapter of Professor Schiaparelli's memoir as the new astronomical theory of luminous meteors, about to be further developed and applied to the explanation of their phenomena.

In the second and third chapters some points of the theory of the atmospherical origin of meteors are regarded as requiring special consideration and discussion. Deviations from uniform motion, such as crooked paths * and changes of velocity, regarded by M. Coulvier-Gravier as the effects of violent air-currents, are shown to arise from the resistance of the air to the original motion of the meteors. The diurnal variation of frequency, noticed by M. Coulvier Gravier, and the similar annual variation, also observed by him, by Dr. Schmidt, Dr. Wolf, and by others, together with the variations of the average direction of meteors throughout the day, or year, are shown to have no direct connexion with meteorological changes, but to correspond to the varying altitude and azimuth *of the apex of the earth's way*, from which the greater number of meteors are directed.

Formulæ for calculating the amount of these periodical variations led Prof. Schiaparelli, in his first letter to Father Secchi, to regard the real velocity of meteors as identical with that of bodies revolving in parabolic orbits round the sun. They were similarly investigated and employed by Professor Newton in pointing out the resemblance of the orbits of shooting-stars to those of comets. A popular account of the phenomena of meteoric variations is given at the conclusion of the chapter, by supposing a "meteoric sun," or central radiant-point of shooting-stars, to be situated at the apex of the earth's way—whose rising and setting produce a meteoric morning and evening, and its culminations a meteoric noon and night, *six hours before* the corresponding changes of the sun. A meteoric spring and autumn, summer and winter are a consequence of the varying declination (or meridian altitude) of the same "meteoric sun," and accordingly follow *three months after* the corresponding tropical seasons of the year.

* Of meteors with decidedly crooked paths, M. Coulvier-Gravier reckons that about three such meteors are visible in every thousand. Meteors with decidedly serpentine flights were only observed by him three or four times in the course of many years. M. Schiaparelli further suggests that the helix, or spiral curve in which small strips of card, 2 inches long and $\frac{1}{4}$ inch wide, descend through the air when let fall from a height, combined with the foreshortening and exaggerating effects of perspective, faithfully represents all the peculiarities of curved and retarded flight occasionally observed in shooting-stars.

In the fourth and fifth chapters, the positions of all the known radiant-points of the northern hemisphere, with respect to the terrestrial apex, are projected by Prof. Schiaparelli on a single planisphere, having the pole of the ecliptic at the centre, and the sun and anthelion, and the apex and anti-apex, at the four points of the ecliptic, in the border of the planisphere. It thus appears that, owing to the generally low position of the sun beneath the horizon during the time of the observations, no radiant-points within 60°, and only twelve radiant-points within 90° of the sun have been observed, the remaining thirty-nine radiant-points belonging to the anti-solar hemisphere, a large portion of which, at night, was in the observer's view throughout the time. On the other hand, thirty-one points of radiation of shower-meteors are found within 90° of the apex, and only twenty occur within 90° of the anti-apex of the earth's way*, although the apex was seldom seen above, and the anti-apex was rarely hidden below the horizon during the observations. The practical results of observation, therefore, confirm the supposition that the apex of the earth's way is also an apex of concentration of meteoric showers, and that consequently the "resultant," or average flight of meteors, taken collectively throughout the whole year, is from the direction of that apex.

Projection of Radiant-points of the northern hemisphere (see Report for 1864, pp. 99, 100), showing their relative positions with respect to the circle of the ecliptic and to the apex of the earth's way. By G. V. Schiaparelli.

* The proportion derived from theory is 43 : 8, or $5\frac{1}{2}$: 1. The practical difference of the result may be accounted for by the large preponderance of evening observations.

No trace of conformity to the ecliptic, or other signs of connexion of the radiant-points with each other or with great circles of the sky, can be detected, which would materially facilitate precise calculation of the diurnal and annual variations, if certain other elements of abundance of the meteors of particular showers were satisfactorily determined.

Allowing for the effects of the earth's velocity in its orbit, in assembling the apparent positions of the radiant-points of shower-meteors about that point of the ecliptic towards which the earth moves, and for the greater chances of vision of small comets when moving in direct orbits nearly coinciding with the ecliptic plane, than of those whose orbits are more inclined, or retrograde, Prof. Schiaparelli considers that both comets and meteors are distributed without any preponderance towards the plane of the ecliptic, and that they exhibit no prevailing tendency towards a direct rather than towards a retrograde motion in their orbits.

The real mean velocity of shooting-stars may be determined from that of comets in their orbits, at their points of intersection with the orbit of the earth, which is 25·70 B. S. miles per second; while that of the earth in its orbit is only 18·18 miles per second*. Adding and subtracting these numbers, the greatest and least mean relative velocities of meteors which encounter the earth (respectively, moving to meet it directly, or to overtake it), no account being taken of the earth's attraction, are 43·88 and 7·52 miles per second. The effect of the earth's attraction is greater in the latter case than in the former (in the proportion of 5 : 1), and increases the mean greatest and least relative velocities of shooting-stars respectively to 44·43 and 10·23 miles per second, which are to each other in the proportion of 4·34 : 1. Supposing, then, that the whole *vis viva* of meteors is converted into heat and light, the heat developed on the surface of those which move to meet the earth directly is greater than that developed by meteors which directly overtake it, in the proportion of 19 : 1. It follows that the light and also the number of meteors in the former case visible to the naked eye will be proportionately greater than those in the latter; and should two meteorites of exactly equal masses penetrate the atmosphere, one of them moving from the direction of the apex of the earth's way with the mean maximum velocity of meteors relatively to the earth, and the other from the opposite direction with the mean minimum velocity, the former meteorite may be totally volatilized, while the latter may reach the earth with a portion of its substance unconsumed, and may produce an aërolitic fall. In this manner Prof. Schiaparelli accounts for a fact which may at least be regarded as pretty well established †, that the greater number of aërolitic falls take place in the afternoon and evening hours of the day, although meteoric phenomena, generally, are then least vivid or abundant, because at that time, which corresponds to *meteoric night, the anti-apex* of the earth's way is at its highest point above the visible horizon, and the meteoric showers which then make their appearance are for the most part moving in direct orbits, so as to overtake the earth with the minimum meteoric speed.

Although no aërolites are precipitated from the meteor-currents of the "Perseids" and "Leonids," the elongations of whose radiant-points from the

* Taking for the amount of the solar parallax its new value, 8″·95. The velocity both of the earth and of particular meteors may differ sensibly from the mean value. Thus, for Biela's comet, whose periodic time of revolution is 6·7 years, the elliptic velocity at the point where it crosses the earth's orbit is 1-14th part less than that of a parabolic orbit, or about 23·9 B. S. miles per second. The real velocity of the November meteors at the same point in their orbits is about 25·07 miles per second.

† See these Reports for 1860, p. 117.—Table to Mr. Greg's Catalogue of Aërolites.

apex of the earth's way are only 38° and 10° respectively, yet other circum-apical meteoric streams may give rise to aërolitic falls. The annual variation of frequency of aërolites is not nearly so marked as the corresponding law of their diurnal variation *; and this would actually be the case, if the materials of a few meteor-currents near the apex should, occasionally, produce aërolitic falls.

The sixth chapter contains some propositions relative to the effects of the earth's motion, and of its attraction, during its appulse with meteoric currents. Supposing D to be the real density or number of meteors per minute of a shower of shooting-stars which would fall on a single horizon exposed vertically to it *were the earth at rest*, z the apparent zenith-distance, and e the apparent elongation of the radiant-point of the shower from the apex of the earth's way, then, considering the real velocity of meteors to be that of bodies moving in parabolic orbits, and to be unaffected by the earth's attraction, the apparent density d, or the number of meteors actually observed per minute, is given by the formula

$$d = D \cos z \sqrt{\tfrac{3}{2} + \sqrt{2} \cos e},$$

and will generally depend on the apparent angular distance of the radiant-point from the zenith of the observer, and from the apex of the earth's way. The frequency of the meteors will be greatest when the radiant-point coincides with the apex of the earth's way, and when both points are in the observer's zenith †. Applying the formula to calculate the real density of the meteors in the great shower of the 13th and 14th of November 1866, from the apparent density (123 meteors per minute) as observed at Greenwich, making $z=65°$, $e=10°$, the value of D, or the real density of the stream for the observers of the shower at Greenwich, is found to be 171 meteors per minute. The effect of the earth's motion through the swarm, in increasing the frequency of the meteors, was thus much more than counterbalanced by the low position of the radiant-point, tending to reduce their apparent number. Had the latter point been in the zenith, the number of meteors recorded in a minute would have been 291, instead of 123, as observed, and would greatly have increased the splendour of the display.

The effect of the earth's attraction cannot always be neglected ‡, as it deflects the parallel courses of the meteors into hyperbolic curves. And those meteors are most deflected which just graze the earth's atmosphere, and which overtake it with the slowest speed from the direction of the anti-apex; the total deflection in this case, on leaving the sphere of the earth's attraction, is 34° 40′; meteors so diverted from their original course become truly *sporadic*, and their radiant-region must speedily grow diffuse; but in the case of a meteor-current arriving from the direction of the apex, the total deviation cannot exceed 1° 24′; while for meteor-currents having their apparent points of divergence midway between these points, or situated 90° from the apex, the greatest possible deviation is 7° 56′. As the meteors of the 13th–14th of November diverge nearly from the apex of the earth's way, and a second deflection of the same meteors to the utmost extent of 1° 28′ is very unlikely to take place, the great accuracy of divergence of the meteors of this shower from a well-defined radiant-point is readily explained.

* See the Table in the above Report for 1860, p. 116.

† For in that case $\cos e = \cos z = 1$.

‡ See an important article by Prof. Twining in reference to the influence of the earth's attraction on "The August Meteors," in the American Journal of Science for November 1861, vol. xxxii.

Meteors which penetrate the atmosphere are deflected downwards; and the apparent position of their radiant-point is deflected upwards to an extent depending on its zenith-distance, by the same cause, termed by Prof. Schiaparelli the *zenithal attraction*—which follows a law very similar to that of atmospheric refraction, in displacing the apparent position of the radiant-point upwards, towards the observer's zenith. The apparent displacement disappears at the zenith, and reaches its greatest value at the horizon, where it may amount in extreme cases to 17° 20′; so that a radiant-point may change its apparent place in the sky (from the effects of the earth's attraction alone) 34° 40′ in twelve hours, between the times of its rising above the horizon in the east point and setting below it in the west. A correction for zenithal attraction is therefore necessary to be applied to the observed positions of all radiant-points whose elongation is greater than 90° from the apex of the earth's way; and formulæ for its calculation, in every case, are given at pp. 56, 57 of the memoir.

The seventh chapter gives an account of the perturbations produced by the earth and the other planets on meteoric swarms with which they come in contact, or which pass in their immediate neighbourhood. Meteors moving in parabolic orbits, which overtake the earth with the least possible relative velocity, may, under the most favourable circumstances, be diverted into ellipses of periodic times varying from $4\frac{1}{3}$ to 120 years or upwards, according as they just graze the earth's atmosphere, or pass at a distance of ten or more earth's radii from its centre. The greatest effect, however, of the earth's attraction on meteors of the November shower is no greater than would alter their periodic time from its present value to 28·67, or to 49·92 years in opposite cases. Since such effects can rarely accumulate, the November meteors can never be diverted into open orbits by the earth's attraction, but will continue to circulate in ellipses, intersecting the earth's orbit, as at present, with little variation, about the earth's place on the 14th of November.

With regard to their introduction into the solar system, it is shown that, on account of the very small difference ($\frac{1}{1446}$ part of the whole) which must exist between the semiaxes major of the foremost and rearmost members of the meteoric group, supposing it to have reached its present extension in its orbit since the year A.D. 902, its actual diameter, if introduced into the solar system by the planet Uranus, could not have exceeded 168 miles. Should its diameter before encountering Uranus have been as much as 600 miles, it must have revolved previously in an ellipse with a periodic time of not more than fifty years, which is as inconceivable as that it should have always continued to revolve without any disturbance in its present course. Should the planets Jupiter or Saturn have effected a diversion of the group from a long elliptic or parabolic orbit into its present path, the possible limits of its original dimensions are much wider, but are still confined to a few earth's radii, supposing that the present track of the group could have brought them sufficiently near to those planets to fall within the extreme boundaries of their attractions—that is to say, within 10·19 radii of the globe of Saturn from its centre, or within 27·27 radii from the centre of the planet Jupiter. The results of this chapter accordingly tend to confirm the opinion urged by Faye*, that the group of the November meteors must have originally formed part *of the nucleus* of Tempel's comet.

The eighth chapter treats of the transformation of materials occupying the celestial spaces into meteoric currents. The hypothesis of Sir W. Herschel

* Comptes Rendus, vol. liv. p. 553 *et seq.*

regarding the concentration of an original nebulous matter* into celestial bodies of the various forms and characters visible in the universe, when applied to the case of shooting-stars, has brought to light the following conclusions, viz. (1) *the production of meteoric streams*, (2) *the affinity of their orbits with those of comets*, (3) *the presence of comets in them forming an integrant part of certain meteor-currents.* Many important considerations are here, accordingly, introduced.

In the first place, in the opinion of Faye, meteor-currents may arise from the dispersion of the nucleus of comets, which Laplace regarded as small portions of the nebulous matter of Herschel overtaken by the sun's attraction in space†. Meteoric clouds Professor Schiaparelli considers to be of exactly the same origin but at the same time of greater extent and tenuity than the nuclei of comets, and, finally, that they assume the form of meteoric currents when (under the influence of the sun's attraction) they approach the interior portion of the solar system. A few general calculations, at the outset, are therefore given, to show what relations the dimensions and the duration of the perihelion passage of the meteoric currents must bear to the original extent and distance of the meteoric clouds, on the supposition that the mutual attractions of their particles may be neglected. It may, however, be shown that if two gravitating spheres, composed of uncohering particles, are placed close together, one of them incomparably smaller than the other, and revolving round it in an orbit, the attraction of the larger sphere will overcome the mutual attraction, and distribute the particles of the smaller sphere in the form of a current along its orbit, unless the smaller sphere has at least twice the density of the larger one. Supposing the sun's mass to be extended into a sphere of the same radius as the earth's orbit, it will contain 2·3 grains weight of matter per cubic yard, which is the density of common air at a barometric pressure of about $\frac{1}{300}$ part of an inch (·00337 in.) of mercury. Twice this density is therefore the least density which a cometary body can have at the earth's distance from the sun, without undergoing gradual deformation by the sun's attraction into an elongated current. In the case of meteoric clouds, which are of extreme tenuity, and have no nucleus, or only such a small nucleus as the November meteors appear to possess in Tempel's comet, the deformation is certain to take place; but in the case of certain comets which appear to possess a nucleus of considerable density, their parts may remain connected throughout their perihelion passage, or at least will not be permanently separated until they approach within a certain distance from the sun. The first steps of deformation of the group of the November meteors may accordingly not have commenced until they were deflected into their present orbit by the forcible attraction of one of the superior planets; and a part of the same group appears still to retain its original compact form in the gaseous mass of Tempel's comet‡.

In this view, comets and meteoric showers are portions of the nebulous matter in space in two different states of condensation (comets or meteors), which may either arise together or apart, according to the tenuity of the mat-

* "Astronomical Observations relating to the Construction of the Heavens," Phil. Trans. for 1811.

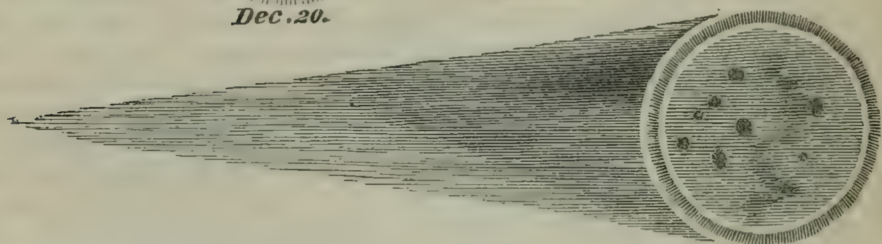
† The occasional smallness of comets may be gathered from a singular observation by Jahn (Astronomische Nachrichten, vol. xxiii. p. 237) of a comet with three tails, which, on the 3rd of July, 1845, described an arc of nearly 40° in about 26 minutes, during which it remained visible. This comet must have passed very close to the earth, and must have been of very small dimensions. (Schiaparelli's Memoir, p. 106.)

‡ The nucleus of this comet was shown to consist of ignited gas, with the spectroscope, by Mr. Huggins (Proceedings of the Royal Society, vol. xv. p. 6, Jan. 11, 1866).

ter which produced them. Such differences are observed in the nebulæ, of which some are resolvable and others not resolvable in the telescope; and a similar distinction is shown to exist in the nebulæ by the spectroscope.

Comets with two or more nuclei, sometimes resembling a congeries of stars, have not uncommonly been observed. Of such observations several descriptions, illustrated by engravings (see fig. 1), are cited, for the details of which the reader is referred to the original memoir (p. 94–101). The extraordinary comet of 1652, witnessed by Hevelius (fig. 2), consisted of a disk of pale light of the apparent diameter of the full moon, with hardly any perceptible tail, and, in the telescope, it appeared filled with points of light. A large proportion of shooting-stars are, in fact, telescopic; and a display of diffused light is said sometimes to accompany a meteoric shower.

Fig. 1.



1. Nucleus of the large comet of the year 1618, observed with a telescope by Cysatus.
2. Comet of the year 1652, as observed and drawn, on the 27th of December, by Hevelius.

How, then, can the ὕλη of Anaxagoras, or the nebulous matter of Herschel become condensed into bodies of such various characters, except it be from a state of highly heated vapour, gradually undergoing a process of cooling and condensing of its parts? Groups of more or less comminuted particles, or compact nuclei would thus result, according as the original form of the heated cloud was that of a filament or thin extended disk, or a sphere. Not only the various features of star-showers and comets, but even the mineralogical structure of aërolites, whose crystals appear to have been deposited from a heated vapour, to have been broken up, and to have, in some cases, again undergone metamorphism by heat, before they were finally consolidated, appear to be explained on this supposition. The theory of Faye, that they are developed from the nuclei, and of Secchi, that they are the remnants of the tails, and of Erman, that they are particles detached from comets by a resisting medium, are not so immediately referable to the known laws of gravitation as the hypothesis that all classes of luminous meteors, like comets themselves, are drawn towards the sun by its attraction from the regions of intrastellar space, which the telescope declares to be empty, but which, in all probability, are strewed with cosmical clouds, containing in one order of phenomena both meteoroids and comets.

The ninth and tenth chapters of the memoir conclude with some further notices and reviews of recent opinions regarding the connexion between comets and shooting-stars, and demonstrations concerning a certain luminosity of

the zodiacal light completely surrounding the ecliptic, termed by German astronomers the *Gegenschein*, of which M. Schiaparelli has himself frequently corroborated the appearance at Milan. It will be sufficient to notice, in closing the present abstract, that the result of the investigation *is not favourable* to the assumption that the outer portion of the zodiacal light consists of solid bodies, shining by borrowed light which they reflect to us from the sun.

"Synthesis of Meteorites." By M. Daubrée (Comptes Rendus, 1866, Jan. 29–March 19, vol. lxii. pp. 200, 269, 660).—By the help of a high heat*, in one of the gas-manufactory furnaces of Vaugirard, supplied with gas-coke, M. Daubrée succeeded in liquifying the intractable materials of upwards of thirty different aërolitic falls. After solidifying, the fused mass was found to consist of a vitrified slag in the case of the three unique meteorites of Juvenas†, Jonzac, and Stannern, which differ from the ordinary type of aërolites in the presence of alumina. The magnesian or common type of aërolites, on the other hand, separates on cooling into two distinct and regularly crystallized minerals, one of which forms a pellicle of square-based, octahedral, or occasionally lamellar crystals, and is peridot, or protosilicate of magnesia. The meteorite of Chassigny consists entirely of this mineral, with a small percentage of chrome-iron ore. The other mineral, of which the meteorite of Bishopville is almost entirely composed, is enstatite, or bisilicate of magnesia. It crosses the centre of the mass, apparently on account of its greater fusibility, in groups of long square prisms, of very perfect form, and generally in one direction. The crucibles being lined with charcoal to preserve the contents from contact with the air, a portion of the iron contained as silicate is reduced; and the silica set free, combining with a portion of the peridot, thereby increases the quantity of enstatite. The ease with which these two minerals crystallize from the liquid state makes it probable, as supposed by Mr. Sorby, that the confused mass of very small broken and imperfect crystals of which the magnesian aërolites consist must have been deposited by sublimation, like flour of sulphur, from a state of heated vapour.

In order to test the affinity of terrestrial rocks with aërolites in this respect, several magnesian silicates were fused, and those which gave results most similar to those of aërolites were found to be,—1°, Peridot from the basalts of Langeac (Haute Loire); 2°, Peridotic hypersthene from Labrador; 3°, and especially, Lherzolite (a mineral found at many places in the Pyrenees) from Prades, consisting of a mixture of the magnesian minerals of peridot, enstatite, and pyroxene. The result of fusion of these rocks, in the presence of charcoal, is exactly similar to that of aërolites: the two magnesian silicates contained in them crystallize separately; and the reduced iron extracted from the mass contains a proportion of nickel, which, as shown by Stromeyer, is present, with phosphates (found by G. Rose, and by M. C. St.-Claire Deville in Vesuvian lavas), as well as chromite, in most of the basic rocks which spring from a source below the granite. A phosphate (apatite) was also found by Rammelsberg, together with titanium, in the rare aluminic meteorite of Juvenas; but the presence of titanium in meteorites of the common or magnesian type was first discovered by M. Daubrée, in the course of his experimental fusions of the meteorites of Montréjau and Aumale.

Several attempts to imitate meteoric iron by fusion were partially successful, as in the liquefaction and reduction of lherzolite and the peridot of

* The heat of melting platinum was employed throughout the experiments.

† In the case of Juvenas, the mass, on solidifying, is porous and full of air-bubbles, as if gas were disengaged from the meteorite at a high heat.

Langeac. The fusion of iron alloyed with nickel and phosphuret of iron produced reticulated figures on the etched sections, which, although not so regular as those of Widmanstätten, were yet perfectly distinct. The formation of small spherules of bisilicate was also repeatedly noticed in the results of terrestrial fusions, which are abundant in certain aërolites; while the graphitic-looking friction-planes met with in many meteorites could be perfectly imitated, by rubbing together fragments of the reduced iron-bearing residue of the fusion of terrestrial rocks.

The serpentine or hydrated class of magnesian rocks were next submitted to experiment—first, in crucibles lined with calcined magnesia, and afterwards alone. The result in the first case is a perfectly crystalline peridot, and in the second case a group of mixed crystals of peridot and enstatite. When the crucibles are lined with charcoal, the resulting mass contains a highly nickeliferous metallic iron*. Most of the serpentines also contain chromite, which was first pointed out by Laugier as an ingredient of the most constant and regular occurrence in meteorites.

Serpentine, basaltic peridot, and lherzolite may accordingly be regarded as the chief terrestrial rocks of a meteoric type. With granite and gneiss, the two staple foundations of the earth's crust, meteorites have no features in common,—neither orthose, felspar, mica, quartz (the meteoric iron of Toluca, according to G. Rose, alone excepted), tourmaline, nor any of the common granitic silicates being found in them. But they agree closely with those basic rocks whose origin is deeper-seated than the granite, and which only reach the surface in volcanic eruptions. They consist most largely of peridot, which is, perhaps, only entirely absent from the three aluminiferous meteorites already mentioned. Its great specific gravity and general distribution in volcanic rocks, its avidity for silica (directly opposed to granite as the most basic of all the known silicates), and lastly, its abundant occurrence in aërolites appear to constitute the character of peridot as the true "universal scoria."

Inasmuch as carbon, in the form of graphite, is rarely found in meteoric iron, it could not be the reducing agent to which aërolites appear to owe their low degree of oxidation; while their reduction by hydrogen would give rise to the formation of water and of hydrates, which are only known to exist, as M. Wöhler has shown, in the carbonaceous meteorites of Orgueil, Kaba, and Cold Bokkeveldt. To explain the presence of such ingredients as metallic iron and unoxidized sulphur and phosphorus in meteorites, a process of oxidation of the original substances may, on the contrary, be supposed to have taken place, which was either incomplete on account of a deficiency of oxygen, or otherwise imperfect by reason of some interruption arising in its action. In order to submit the effects of such a process to experiment, unoxidized siliciuret of iron was heated in a crucible, in contact with calcined magnesia, with a very slight access of air. Silica was thus produced, and it combined with the calcined magnesia in the form of peridot, while the iron was left in a metallic state. In another experiment, an alloy of iron containing 9 per cent. of nickel, with sulphuret and phosphuret of iron, silica, and magnesia, were heated together in a Schloesing's gas-furnace, with the same precaution as before of admitting a slight access of air. The resulting peridot was olive-coloured, containing iron, and was without a trace of nickel, exactly as it is found enclosed in the meteoric irons of Pallas and Atacama.

* The chemical analyses in this and the following experiments were conducted by M. Stanislas Meunier, the assistant in the geological laboratory of the Paris Museum of Natural History.

The remaining metallic iron was more rich in nickel than before, and contained, besides, the sulphuret of iron combined together with the phosphuret, in the form of the triple phosphuret of iron, nickel, and magnesium (discovered in meteorites by Berzelius), which was separated from the iron by acid in metallic-looking grains.

A synthesis of the chief ingredients of aërolites being thus found possible without the use of reducing agents, M. Daubrée is finally disposed to adopt the opinion that aërolites originally underwent a process of scorification, accompanied by incomplete oxidation, or a species of *natural cupellation**, in which the substances having most avidity for oxygen were first completely oxidized, and the less chemically active elements and metals remained partly in the uncombined state, or alloyed with each other. The complete analogy, which this view presents to the generally received opinion regarding the formation, by oxidation, of the earth's crust, recommends its unreserved adoption as the description of a cosmical process only differing from that recognized on the earth by its particular degree of completeness or duration. The highly oxidized materials, the absence of metallic iron, and the conversion of phosphurets and sulphurets in the earth's crust into phosphates and sulphates, may be considered to have resulted from the same process of scorification, accompanied by a far more advanced oxidation than that concerned in the formation and metamorphoses of meteorites.

In a later reprint of the same paper † M. Daubrée gives the following Table of the specific gravities of eruptive rocks and basalts, showing the superior gravity of peridot to all of them, closely approaching the ordinary specific gravity (3·35) of aërolites :—

Granite......	2·64–2·76	Basalt......	2·9–3·1
Trachyte	2·62–2·88	Enstatite...	3·303
Porphyrite...	2·76	Lherzolite ..	3·25–3·33
Diabase.....	2·66–2·88	Peridot	3·33–3·35

Continuing his researches on the composition of aërolites ‡, a new classification of aërolites, founded on the amount and mode of distribution of metallic iron in them, was suggested. The process adopted for this classification was proposed by M. S. Meunier, and resembles that commonly employed in the extraction of metallic gold from its matrix in quartz rocks. A fragment of the aërolite, supported by an iron wire, is heated to redness in a current of carbonic acid gas, and while still red-hot it is suddenly chilled by plunging into mercury. The siliceous portions of the aërolite are then easily crushed out from the interstices of the iron, and the mode of distribution of the latter is most clearly distinguished: 1°, when the mass of iron is solid, the meteorite is termed a *Siderite*; 2°, when it forms a continuous network in which the siliceous matter is included or interlaced, the meteorite is a *Syssiderite*; 3°, when the iron forms separate grains, or is discontinuous, as generally occurs in aërolites, the meteorite is a *sporado-siderite*; 4°, *Cryptosiderites* are those which exhibit a total absence or only very doubtful traces of metallic iron. In the Syssiderites of Pallas and Atacama the siliceous parts are discontinuous; but in that of Rittergrün they form, like the iron itself, a continuous mass, interwoven with the iron.

* An expression used by M. Elie de Beaumont to describe the same process as it is supposed to have originally operated on the earth (Bulletin de la Société Géologique de la France, 1847, 2nd ser. vol. iv. p. 1326).

† *Ibid.* 2nd ser. vol. xxiii. p. 408, March 5, 1866.

‡ Comptes Rendus, vol. lxv. pp. 60, 148 (July 22, 1867).

On Spherules in Meteorites (Note by Mr. H. C. Sorby).—" The small globules of iron thrown off in the Bessemer process have a structure more like that of the globules in meteorites than any that I have ever seen. I do not know any concretion in terrestrial rocks like them. The Bessemer globules are thus , whilst the concretions in rocks are thus ; and, as you see, the former is just the character of those in meteorites."—(Letter to Mr. Greg; Sheffield, June 23rd, 1866.)

" Meteors, Aërolites, and Falling-stars." By Dr. T. L. Phipson *.—A recapitulation of known facts and theories, rather than a work of original research, this little volume yet contains a mass of interesting information, and of observations, not hitherto brought together into one book. The following passage, briefly abstracted from pp. 172–178 of the work, conveys the ingenious opinion of the author on the early history of aërolites, fireballs, and shooting-stars, ascribing to them a community of origin with the earth, as supported by the then existing results of astronomical, and chemical researches on aërolites and falling-stars, made known in the previous pages of the work.

" The chemical portion of this interesting problem has been completely solved; aërolites are shown to be *of the nature of the earth*. And if we combine for a moment the planetary theory [of aërolites] and the fact that the large aërolites fall generally during the day, whilst the large bolides (either silent or detonating) appear usually soon after sunset, and shooting-stars (especially the November and August swarms) always in the night †, we are forcibly drawn to the conclusion that our earth circulates round the sun in or near a *continuous cloud of its own dust* (matter thrown from it during the earlier periods of its existence), and that this dust is distributed in such a manner that its larger fragments circulate inside the earth's orbit (*v.* A. S. Herschel, 'Intellectual Observer,' April 1865) and gradually decrease in size as they extend beyond this orbit; hence the phenomena of aërolites, bolides, and shooting-stars...... If in future years extended observations enforce upon us the truth of the assumption that meteoroids are really the *dust of the earth*, fragments of the earth's mass thrown from it in early years (when volcanic action was intense, probably long after the moon was separated from it), which myriads of fragments have continued ever since to circulate along or near to the earth's path, then I shall be satisfied to have originated this theory."

Since this was written, the remarkable and probably more correct theory of the cometary and *extra-planetary* origin of meteors, advanced by M. Schiaparelli, has been favourably received by astronomers and meteorologists.

'Meteoric Astronomy; a Treatise on Shooting-stars, Fireballs, and Aërolites.' By Daniel Kirkwood, LL.D., Professor of Mathematics in Washington and Jefferson College, U. S.‡

This treatise is a somewhat more condensed and scientific work than the last. In the first two chapters the history and character of the ring of the November meteors are described at length, and the recent theory of M. Schiaparelli on the August and other meteoric rings is specially noticed. The

* Lovell Reeve and Co., London, 1867.

† The greatest rate of frequency of shooting-stars, occurring in the morning hours of the night, or, on the average of the whole year, between 3 o'clock and 6 o'clock A.M., is here referred to.

‡ Trübner and Co., London, 1867.

third chapter contains a catalogue of stonefalls, in chronological order; and the 4th–11th chapters, discussions of various questions in the theory of meteors, such as:—the relative number of meteoric falls during the different parts of the day, or year; the coexistence of different forms of meteoric matter in the same rings; meteoric dust; the stability of the solar system, and the hypothesis of a resisting medium; the extent of the atmosphere as indicated by meteors; the chemical and mechanical theories of solar heat; and the explanation of temporary and variable stars by the revolution round them of meteoric rings. In the 12th chapter, the rings of Saturn are regarded as examples of such formations, the principal gap or interval between them being thus especially accounted for. The 13th chapter treats of the zone of asteroids; and in the concluding chapter of the work the Nebular Hypothesis is represented as giving an intelligible explanation of the origin of meteoric streams *. A condensation of nebulous matter, "it is thus seen, accounts satisfactorily for the origin of comets, aërolites, fireballs, shooting-stars, and meteoric rings."

In summing up the result of his conclusions (pp. 120–122), Dr. Kirkman cites the recent calculations of Leverrier and Schiaparelli on the remarkable connexion observed to exist between Tempel's comet (I. 1866) and the group of the November meteors; of which group the comet appears to constitute the nucleus. The probable periodic time (about 105 years) of the August meteoric ring is also noticed, the similarity of its elements to those of the orbit of the third comet of 1862, and the remarkable circumstance, first pointed out by Schiaparelli, that a nebulous mass drawn into the solar system from without will be deformed in its approach, so as to pass the sun in a very narrow stream, and that if it returns in an elliptic orbit it will, after a certain number of revolutions, be converted into a continuous ring of material substance. The aërolitic epoch of the 27th–30th of November may, perhaps, be produced by such a ring connected with Biela's comet, near the orbit of which the earth annually passes at about that date.

With regard to aërolites, it is observed that they are more frequent

(1) by day than by night,
(2) in the afternoon than in the forenoon,
(3) when the earth is in aphelion than when it is in perihelion.

The first of these conditions is accounted for by the difference in the number of observers. The second indicates that the orbital motion of aërolites is generally direct; and the third is dependent on the greater length of the day in the apheliac than in the periheliac portion of the year. The asteroidal space between Mars and Jupiter is not impossibly a wide meteoric zone in which the largest aggregations are visible to us as the minor planets. The zodiacal light may also be regarded as an immense swarm of meteor asteroids; and, finally, the meteoric theory of solar light and heat is included in the treatise as a consequence of the same form of the nebular hypothesis.

* At p. 30, speaking of the radiant-point of the 19th–20th of April meteoric shower, Dr. Kirkwood states, on Mr. Greg's authority, that it is about Corona. This mistaken estimate of its position, from an imperfect view of the phenomenon on the night of the 20th of April, 1863, was given by Mr. A. S. Herschel in a lecture delivered a few days later, at the Royal Institution, in London. The position of the radiant-point was more accurately determined in the following year (see these Reports for 1864, p. 98), and it was then found to coincide with the place assigned to it by Herrick, in 1839, "near α Lyræ."

Meteors observed at Cambridge Observatory, August 8th, 1868.

No.	Magnitude, α, β, γ.	Angular Direction by Clock-face, or Position-circle.	True Greenwich Mean Time of Observation.	Azimuth corrected for Index-error.	Zenith-distance corrected for Index-error.	Notes.	Observer.
			h m s	° ′	° ′		
1.	α	......	10 5 26	....	......	....	Mrs. Adams.
2.	γ	......	10 9 46	....	......	Near to γ Andromedæ, from a little above γ Persei to γ Andromedæ.	Eadem.
3.	γ	88°	10 18 18	268 9	45 36	Under clouds	Prof. Adams.
4.	α	104°	10 30 38	237 21	51 36	Train	Idem.
5.	γ	......	10 37 30	....	......	From a faint star above the line joining α and β Andromedæ to ♃.	T. Adams.
6.	γ	5^h	10 46 18	....	......	From ϵ Pegasi	Mrs. Adams.
7.	......	......	10 49 48	....	......	From δ Ursæ Minoris to γ.	T. Adams.
8.	v. small	......	11 1 27	....	......	Just above α Ophiuchi and α Herculis towards Corona.	Mrs. Adams.
9.	......	......	11 7 58	....	......	Seen through clouds	Ead.
10.	β	99°	11 14 55	326 27	17 6	Short train	Prof. Adams.
11.	β	270°	11 17 15	277 45	21 6	....	Id.
12.	α	$4\frac{1}{2}^h$	11 21 13	....	......	From β Aquilæ	Id.
13.	......	3^h	11 25 48	....	......	From α Cephei	T. Adams.
14.	β	......	11 27 40	....	......	Recorded by Prof. Challis.	Prof. Challis.
15.	β	65°	11 37 4	190 39	11 6	....	Prof. Adams.
16.	α	96°	11 44 8	342 21	81 18	Observed likewise by Prof. Challis.	H. T.
17.	......	5^h	11 46 24	....	......	Train	Mrs. Adams.
18.	......	4^h	11 46 29	....	......	Train	Ead.

August 10th, 1868.

No.	Magnitude, α, β, γ.	Angular Direction by Clock-face, or Position-circle.	True Greenwich Mean Time of Observation.	Azimuth corrected for Index-error.	Zenith-distance corrected for Index-error.	Notes.	Observer.
1.	γ	6^h	10 2 29	....	......	Halfway between Arcturus and Cor. Car.	Mrs. Adams.
2.	β	281°	10 7 25	164 31	30 52	....	Prof. Adams.
3.	β	......	10 8 48	....	......	Train; a little above α, and a little below δ Ursæ Maj.	Mrs. Adams.
4.	β	258°	10 9 57	104 7	59 46	....	Prof. Adams.
5.	β	......	10 16 13	....	......	Through the head of Draco.	Mrs. Adams.
6.	......	65°	10 21 53	346 37	59 40	....	Prof. Adams.
7.	γ	121°	10 24 8	331 37	59 22	....	Id.
8.	......	......	10 25 43	....	......	Towards ψ Ursæ Majoris, from between β and ϵ.	Mrs. Adams.
9.	......	......	10 33 31	....	......	From α to ϵ Cygni...	H. G.
10.	......	......	10 33 51	....	......	In Ursa Maj.; small	Mrs. Adams.
11.	......	......	10 33 54	....	......	Ditto; ditto	Ead.
12.	......	......	10 33 55	....	......	Ditto; ditto	Ead.
13.	γ	......	10 38 35	107 13	59 16	From α Ophiuchi ...	H. G.
14.	β	309°	10 41 7	292 55	62 10	....	Prof. Adams.
15	......	......	10 42 9	263 1	34 34	Towards α Androm..	Mrs. Adams.
16.	......	......	10 43 1	....	......	....	Ead.
17.	......	......	10 43 54	....	......	Near Capella	Ead.

No.	Magnitude, α, β, γ.	Angular Direction by Clock-face, or Position-circle.	True Greenwich Mean Time of Observation.	Azimuth corrected for Index-error.	Zenith-distance corrected for Index-error.	Notes.	Observer.
			h m s	° ′	° ′		
18.	β	4^h	10 45 37	350 55	64 22	....	H. G.
19.	β	......	10 48 35	....	......	From ζ Cygni to slightly west of Delphinus; good train.	Mrs. Adams.
20.	......	$5\frac{1}{4}^h$	10 52 35	24 49	53 34	....	H. G.
21.	γ	165°	10 55 53	57 37	56 46	....	Prof. Adams.
22.	......	$4\frac{1}{2}^h$	10 56 12	....	......	Through α Aquilæ ...	H. G.
23.	α	4^h	11 5 52	353 43	59 46	Train	Id.
24.	γ	5^h	11 9 1	....	......	Slightly to left of α Arietis.	Mrs. Adams.
25.	β	$7\frac{1}{2}^h$	11 11 14	204 37	67 46	Short train	Ead.
26.	......	$2\frac{1}{2}^h$	11 14 25	244 55	34 16	Fine train; remained visible some time in Cassiopeia.	Ead.
27.	γ	......	11 17 30	....	......	....	Ead.
28.	β	2^h or $2\frac{1}{2}^h$	11 21 57	256 25	40 22	Train	Ead.
29.	γ	......	11 28 17	....	......	From a little below Polaris, very little below κ Draconis.	Ead.
30.	......	......	11 37 53	....	......	From a little above Polaris to ζ Ursæ.	Ead.
31.	β	112°	11 31 17	343 55	14 40	....	Prof. Adams.
32.	γ	5^h	11 34 34	63 7	59 16	....	H. G.
33.	γ	5^h	11 37 51	45 37	44 58	....	H. T.
34.	......	$4\frac{1}{2}^h$	11 41 27	350 49	44 40	....	H. G.
35.	......	......	11 45 6	....	......	....	Mrs. Adams.
36.	......	......	11 45 15	....	......	....	Id.
37.	γ	25°	11 45 54	190 1	56 34	....	Prof. Adams.
38.	β	4^h	11 47 20	17 43	60 52	Train	H. T.
39.	......	9^h	11 50 49	117 13	60 16	Very slow	Prof. Adams.
40.	......	6^h	11 54 23	68 49	64 10	....	Mrs. Adams.
41.	......	8^h	11 54 42	....	......	Over η Ursæ	Ead.
42.	......	......	11 56 54	....	......	From β Ursæ, line joining α and β.	Ead.
43.	......	5^h	11 57 4	182 31	65 46	....	Ead.
44.	......	9^h	11 59 10	91 1	30 22	Short train	Ead.
45.	β	$5\frac{1}{2}^h$	12 3 3	169 43	55 40	....	Ead.
46.	......	$10\frac{1}{2}^h$	12 5 46	210 25	26 46	....	Prof. Adams.
47.	......	$8\frac{1}{2}^h$	12 6 39	147 25	62 10	....	Id.
48.	α	255°	12 7 49	113 37	64 46	Train	Mrs. Adams.
49.	......	7^h	12 9 16	159 25	69 28	....	Ead.
50.	......	8^h	12 10 29	122 31	63 46	....	Prof. Adams.
51.	......	$\left\{\begin{matrix}8^h\\239°\end{matrix}\right\}$	12 16 34	78 1	62 46	....	Id.
52.	α	220°	12 22 7	102 31	68 40	A very fine train ...	Id.
53.	γ	$\left\{\begin{matrix}8^h\\235°\end{matrix}\right\}$	12 23 50	159 25	68 34	....	Mrs. Adams.
54.	......	5^h	12 27 38	22 31	62 16	....	H. G.
55.	α	284°	12 28 30	202 31	27 10	Train	Prof. Adams.
56.	......	7^h	12 3 9	171 31	62 40	....	Mrs. Adams.
57.	β	$7\frac{1}{2}^h$	12 38 32	153 31	42 40	....	Ead.
58.	γ	7^h	12 42 57	168 37	55 22	....	Prof. Adams.
59.	......	......	12 46 55	....	......	Vanished at α Andromedæ; came from a point midway between Cassiopeia and α Andromedæ.	Id.

TABLE (*continued*).

No.	Magnitude, α, β, γ.	Angular Direction by Clock-face, or Position-circle.	True Greenwich Mean Time of Observation.	Azimuth corrected for Index-error.	Zenith-distance corrected for Index-error.	Notes.	Observer.
			h m s	° ′	° ′		
60.	......	8^h	12 50 3	....	......	Across α Lyræ	Prof. Adams.
61.	......	$7\frac{1}{2}^h$	12 57 54	....	......	Through ζ Ursæ......	Id.
62.	γ	5^h	13 1 4	....	......	From below α Aquilæ	H. G.
63.	......	$\left\{\begin{matrix} 7\frac{1}{2}^h \\ 233° \end{matrix}\right\}$	13 4 55	212 37	54 28	....	Prof. Adams.
64.	β	6^h	13 8 9	83 13	69 40	Train	H. G.
65.	......	......	13 13 9	....	......	....	Prof. Adams.
66.	......	8^h	13 13 12	....	......	Near Polaris	Id.
67.	γ	$8\frac{1}{2}^h$	13 14 58	169 55	55 16	....	Id.
68.	γ	246°	13 17 9	177 55	38 58	....	Id.
69.	γ	$6\frac{1}{2}^h$	13 25 37	70 55	50 28	....	Id.
70.	......	$8\frac{1}{2}^h$	13 29 36	....	......	....	Id.
71.	......	$8\frac{1}{2}^h$	13 29 39	....	......	....	Id.
72.	......	6^h	13 31 50	....	......	....	Id.
73.	β	......	13 35 54	....	......	Very bright	Mrs. Adams.

Observations of Shooting-stars made at the Radcliffe Observatory, Oxford, on the nights of August 8th, 9th, 10th, 11th, 12th, and 13th. Communicated by the Radcliffe Observer.

The times noted (when seconds are inserted) are within a few seconds of Greenwich mean solar time.

August 8th.—

	G. M. T. h m s	
At	9 24 0	A train seen in Cassiopeia, moving from north to south; but the body of the meteor was not seen.
	9 41 0	A meteor appeared close under Polaris; direction from east to west.
	10 0 0	One, of the 2nd mag., in Cassiopeiæ, moving towards the north.
	11 13 0	(2nd mag.) From Polaris, by β Ursæ Minoris; a train.
	11 37 0	From α Persei, downwards.
	11 52 0	From Polaris to north horizon.

The sky was overcast after these observations.

August 9th.—The sky was blackly overcast nearly all the night, with the exception of a small portion in the north, where some of the stars of Ursa Major were visible, the clear sky extending as far as Arcturus in the west.

At	10 30 0	A meteor equal to a star of the 1st mag., of a red colour, moving from a little to the west of η Ursæ Majoris to Arcturus; a train.
	11 3 0	(4th mag.) From β Ursæ Minoris to north horizon.
	11 8 0	(1st mag.) ,, a point somewhat near Capella (which could not be seen for clouds), towards the north horizon, of a yellowish colour.
	11 16 0	(2nd mag.) White; from β Ursæ Majoris, westward; motion very rapid.

At 11^h 20^m, the sky became quite overcast.

August 10th.—Mr. Lucas began to watch about 9 o'clock, and continued to observe till 13^h 20^m, when clouds came up. In the first three-quarters of an hour no meteor was seen.

G.M.T. h m s		
At 9 49 10	(4th mag.)	From η Pegasi to λ Pegasi.
9 52 15	(5th mag.)	„ α Andromedæ to south-east horizon.
9 54 0	....	„ η Pegasi to south-east horizon (seen by Mr. Main).
9 55 +	....	„ η Pegasi, downwards (seen by Mr. Main).
9 57 50	(5th mag.)	„ γ Cassiopeiæ, southwards, in the direction of the Milky Way.
10 2 35	(4th mag.)	„ γ Andromedæ, upwards, towards the south; a train.
....	(1st mag.)	In Perseus (time not noted), seen by Mr. Main.
....	(1st mag.)	Near α Aquilæ (time not noted), seen by Mr. Main.
10 12 0	....	From ζ Ursæ Majoris, westward; a train.
10 15 0	....	Through Cassiopeia, north-east to south-west.
10 31 50	(5th mag.)	From Sagitta, in direction north-west.
10 33 40	(5th mag.)	„ the cluster in Perseus (χ), southwards.
10 37 0	(6th mag.)	„ Cassiopeia, southwards.
10 38 0	....	Two meteors, through Perseus, westwards; seen by Mr. Main.
10 39 50	(6th mag.)	From χ Persei to Cassiopeia.
10 41 0	(6th mag.)	„ Capella, upwards.
10 42 20	....	A meteor appeared for an instant below β Andromedæ, and disappeared at the same place, having no apparent motion.
10 49 0	....	From Cassiopeia towards the south-west (downwards); seen by Mr. Main.
10 52 0	....	„ Polaris to β Ursæ Minoris.
10 53 0	(2nd mag.)	White; from β Draconis, westward; a train.
10 54 0	....	From Cassiopeia, through Ursa Major; train; Mr. Main.
10 55 0	....	„ Cassiopeia to Capella; a train; Mr. Main.
10 55 0	....	Two from Polaris, downwards.
10 56 0	(2nd mag.)	From Cassiopeia to Pegasus; a train.
10 57 0	....	„ h Ursæ Majoris to β Ursæ Majoris.
11 1 0	....	North of Jupiter, southwards (Mr. Main).
11 9 0	....	From Perseus, south-east (Mr. Main).
11 9 23	....	„ Perseus, south-east (Mr. Main).
11 12 10	....	„ Perseus to Andromeda (Mr. Main).
11 14 20	(1st mag.)	„ β Persei to Aries (Mr. Main).
11 16 50	(1st mag.)	„ Perseus to α Ursæ Majoris; a train.
11 18 0	....	„ ditto ditto.
11 19 40	(2nd mag.)	„ α Ursæ Majoris, towards north-west horizon.
11 20 50	....	„ κ Draconis, towards north-west horizon.
11 21 50	....	„ γ Andromedæ, towards east horizon.
11 28 0	....	„ α Arietis, towards Jupiter (Mr. Main).
11 30 0	....	„ β Persei, northwards (Mr. Main).
11 37 0	....	„ α Persei to α Ursæ Majoris.
11 43 10	(2nd mag.)	„ β Ursæ Minoris to Canes Venatici.
11 44 40	....	„ α Coronæ to west horizon.
12 7 0	....	„ α Ophiuchi to west horizon.
12 10 20	(2nd mag.)	„ Polaris to δ Ursæ Majoris; a train.
12 16 50	(2nd mag.)	„ β Draconis to α Coronæ; a train.
12 21 20	....	Midway between η Ursæ Majoris and α Coronæ to west horizon.
12 23 20	....	From γ Ursæ Minoris to α Coronæ.
12 27 20	(4th mag.)	„ η Draconis to α Coronæ.
12 28 20	(2nd mag.)	„ η Persei, downwards.
12 30 20	....	„ β Ursæ Minoris, towards α Coronæ.
12 34 20	(4th mag.)	„ η Draconis, towards Corona.
12 43 20	....	North of Capella, in a line with α Persei, towards north-east horizon.
12 46 25	....	From γ Andromedæ to the Moon.
12 49 0	(4th mag.)	Below the Pole, in a line with Cassiopeia, to α Ursæ Majoris.
12 57 0	(5th mag.)	From o Ursæ Majoris to β Ursæ Majoris.
13 2 0	....	„ Capella, downwards.
13 13 0	....	„ β Persei, downwards.
13 20 0	....	„ ϵ Cassiopeiæ to α Persei.

About 11 o'clock some streamers (probably auroral) were seen by Mr. Main, at an altitude of about 35° above the north horizon. They were at

first mixed up with the Milky Way, but were seen to drift to the west of it in a few minutes, and then they gradually disappeared.

Several flashes of lightning were seen between 11^h and 12^h, a little above the north horizon. No clouds were seen in that part of the sky at the time.

August 11th.—The sky was quite overcast till 9^h, when it suddenly cleared and became intensely bright. At $9^h\ 4^m$, a bright white meteor was seen to come from behind a cloud near the north horizon, very near Capella, which was at that time hidden by the cloud; it took a direction towards β Aurigæ.

	G. M. T. h m s		
At	9 19 0	(2nd mag.)	From 12 Canum Venaticorum to ϵ Virginis.
	9 25 0	(4th mag.)	Under the Pole, westwards.
	9 35 40	(1st mag.)	From α Capricorni, eastward; a train.
	9 40 0	(3rd mag.)	,, between o and h Ursæ Majoris to κ Ursæ Majoris.
	9 41 5	(1st mag.)	,, Polaris to θ Bootis.
	9 53 0	(2nd mag.)	,, Polaris to δ Ursæ Majoris.
	9 59 0	....	,, Ophiuchus, westward.
	....	....	,, Aquarius, southward.
	....	....	,, Polaris to Cassiopeia (Mr. Main).
	10 13 0	(5th mag.)	,, α Aquarii to α Capricorni.
	10 13 0	(1st mag.)	,, α Aquilæ, in the direction of the Milky Way, towards the south-west.
	10 13 0	....	,, γ Ursæ Minoris to ϵ Bootis (Mr. Main).
	10 29 0	(2nd mag.)	,, Sagitta, towards the south-west.
	10 43 45	(2nd mag.)	,, γ Cassiopeiæ to α Lyræ; a long train.
	10 53 55	(2nd mag.)	,, β Draconis to α Ophiuchi; a long train.
	10 56 0	(4th mag.)	,, α Cephei to α Lyræ.
	10 59 0	(4th mag.)	,, α Andromedæ to γ Pegasi.
	11 11 15	(2nd mag.)	,, β Persei to a point a little below α Arietis.
	11 13 25	(2nd mag.)	,, γ Cassiopeiæ to α Cygni; a long train.
	11 16 40	(2nd mag.)	,, β Draconis to α Ophiuchi; a long train.
	11 25 0	....	,, Polaris to α Draconis.
	11 39 0	(4th mag.)	,, β Andromedæ to a point a little to the east of α Andromedæ.
	11 53 5	(1st mag.)	,, a little to the west of Polaris, past α Lyræ to Aquila; a long train.
	11 12 8	(4th mag.)	,, η Draconis to Hercules.
	11 0 15	....	,, Aquila, towards the south-west.

A thick haze came on after this; only the large stars remained visible.

The observations throughout were made by Mr. Lucas, except in cases in which they are denoted as being made by Mr. Main.

August 12th.—Thickly overcast till $10^h\ 45^m$, when the clouds cleared away, leaving a little haze for some time, through which only the larger stars were visible. As the haze disappeared, clouds gradually spread over the sky again. At about 11^h, a cloud, lying in a great circle, extended from the south-east horizon, passing a little to the south of Jupiter under β Pegasi, and by η Ursæ Majoris to the north-west horizon. It slowly travelled northwards till it reached Capella, when it gradually faded away. While passing Andromeda, its width nearly filled the space between α and β Andromedæ. The following meteors were seen afterwards:—

At	11 17 0	(1st mag.)	White; from η Lyræ, in a south-west direction to the Milky Way; a train.
	11 20 0	(2nd mag.)	From Aquarius to α Capricorni; a train.
	11 22 0	(3rd mag.)	,, δ Aquilæ, in a south-westerly direction.
	11 38 0	(1st mag.)	,, β Draconis to α Ophiuchi; a long train.
	11 42 0	(3rd mag.)	,, α Aquilæ, in a south-easterly direction.
	11 52 0	(4th mag.)	,, Polaris to α Draconis.

August 13th.—A strict watch was not kept to-night; but the following meteors were seen by Mr. Lucas:—

G. M. T. h m s			
At 10 49 0	(2nd mag.)	From	Polaris to η Ursæ Majoris.
10 49 0	(3rd mag.)	„	Cassiopeia, southwards.
10 50 0	(1st mag.)	„	below α Pegasi to α Capricorni.
10 54 0	(2nd mag.)	„	Sagitta to α Aquilæ.
11 0 0	(1st mag.)	„	α Andromedæ, past α Pegasi; a train.
11 29 0	(3rd mag.)	„	λ Bootis to γ Bootis (Mr. Quirling).
11 35 0	(2nd mag.)	„	β Pegasi to α Aquarii; a train.
11 37 0	(4th mag.)	„	α Pegasi, in a south-easterly direction.
11 43 0	(5th mag.)	„	Jupiter, southwards.
11 49 0	(4th mag.)	„	ϵ Bootis, towards south horizon (Mr. Quirling).
11 49 0	(5th mag.)	„	γ Pegasi, southward.
11 54 0	(2nd mag.)	„	α Andromedæ to γ Pegasi (Mr. Quirling).
11 59 0	(4th mag.)	„	β Pegasi to Capella.
12 6 0	(1st mag.)	„	below Jupiter to east horizon; motion slow; a train.
12 11 0	(5th mag.)	„	α Pegasi, southward; very rapid motion.
13 18 0	(3rd mag.)	„	α Pegasi to a point between α Andromedæ and γ Pegas (Mr. Quirling).
13 20 0	(4th mag.)	„	β Arietis, northward, passing α Arietis; a train.
13 28 0	(3rd mag.)	A very	little to the east of Jupiter, southward.
13 28 0	(5th mag.)	From	α Persei, eastward.
13 40 0	(5th mag.)	„	a point between ζ and α Pegasi, southward.

Robert Main.

Radcliffe Observatory, Oxford,
August 15th, 1868.

Dear Glaisher,—Enclosed is a list of meteors seen this evening; there were some twenty others (very small), which are not included. The meteors were most abundant between 10^h P.M. and 10^h 15^m P.M., and there were several points of convergence; one in sword-handle of Perseus, and another slightly north of, and above Cassiopeia, accounted for most of the meteors. The paths were very short, of all meteors seen near these points; those meteors in Ursa Major, Ursa Minor, and in south and south-west had very long paths. All were *blue* or colourless, mostly intensely blue, and nearly all had streaks, were very rapid in their movements, and vanished instantaneously. During the last few days there have been several large meteors each evening between 9^h 15^m P.M. and 10^h 15^m P.M. From 11^h P.M., clouds and moonlight interfered much with the observations. The meteor at 9^h 58^m 50^s was very remarkable.

Believe me,
Yours very truly,
E. J. Lowe.

Highfield House, Aug. 10, 1868.

P.S. Evening of 10th cloudy; 11th, from 6^h A.M., thunder-storms and the breaking up of the drought, 2 inches of rain having fallen to-day. From 11^h P.M., stars for a time, but I saw no meteors.—E. J. L.

Meteors seen at Highfield House, August 9th, 1868.

h m s		
9 32 10	G. M. T.	Started 1° north of α Cygni, passing 1° south of Vega, and ending at χ Lyræ. Intense blue; long streak left, which faded rapidly. Size of Vega; moved rapidly.
9 35 15	„	From α Cygni, through ϵ Cygni, to β Delphini; very small; colourless; rapid. The direction almost at right angle to the last.

h m s		
9 36 10	G. M. T.	Started at Polaris, and moved to within 20′ of η Ursæ Majoris. Very rapid; 1st-mag. star; pale blue; exceedingly long streak. (Convergent-point Cassiopeia.)
9 42 0	„	From μ Cassiopeiæ to χ Andromedæ; equal 2nd-mag. star; rapid; blue.
9 46 30	„	From δ to near γ Cassiopeiæ; between these two stars, but not extending to either; very small and rapid; blue. (Convergent-point sword-handle of Perseus.)
9 49 3	„	Second mag. star; long streak. From the star No. 43 Andromedæ ($2\frac{1}{2}°$ above β Andromedæ), and ended 3° below α Andromedæ. (Convergent-point sword-handle of Perseus.)
9 52 4	„	Crossing δ Andromedæ to γ Pegasi; equal 3rd-mag. star; rapid; long pale blue streak. (Convergent-point sword-handle of Perseus.)
9 56 40	„	From μ Cassiopeiæ, across Andromeda, to south; small.
9 56 42	„	From just below the last, and in same direction; both equal 3rd-mag. star, with faint streaks. (Point of convergence of both 3° above sword-handle of Perseus.)
9 58 50	„	In sword-handle of Perseus, a meteor appeared and disappeared without moving, like a blue flash of distant lightning, not more than 40′ in diameter.
10 0 0	„	Rapid; across α Pegasi, down towards south horizon.
10 5 25 [=B.*$10^h 6^m$]	„	From ϵ Pegasi, across ϵ Aquarii; equal 2nd-mag. star; long blue streak; very rapid.
10 6 30	„	Small; across Pisces, moving from north to south.
10 6 50	„	From slightly north of α Cygni across η Pegasi; long streak.
10 8 30	„	Passed just above η Pegasi towards south; very rapid; long streak. (Convergent-point above and north of Cassiopeia.)
10 10 40	„	Across γ Cygni, from direction of a point 5° above χ Cassiopeiæ.
10 12 40 [=B.$10^h 13^m$]	„	5° below Delphinus. (Convergent-point 5° above χ Cassiopeiæ.)
10 13 55	„	Just above η Pegasi, downwards towards south. (Same convergent-point as the last). Large and long streak; blue.
10 17 2 [=B. $10^h 18^m$]	„	Equal twice a 1st-mag. star; intense blue; long streak; very rapid; from π Pegasi, down towards south. (Convergent-point same as last.) (Some cloud for twenty minutes.)
10 45 40	„	Moved from north of Præsepe towards north horizon; very short path.
10 46 0 [?=B. $10^h 47\frac{1}{2}^m$]	„	From Cassiopeia, passed under Polaris, passing between δ and ϵ Ursæ Majoris; above size of 1st-mag. star; blue; very long streak. (Convergent-point above Cassiopeia.)
10 56 20	„	Equal 1st-mag. star; very blue streak; from 30° above north horizon, falling nearly perpendicularly down, slightly inclining west. (Convergent-point sword-handle of Perseus.)
11 1 10	„	From under Polaris, across Ursa Major, from direction of sword-handle of Perseus.
11 3 45	„	A very large globe meteor (six times the size of Jupiter); blue; from 10° below α Aquilæ; fell down the Milky Way, leaving a long train of separate sparks, which lingered after the meteor had vanished. (H. L. P. Lowe.) (More clouds of phosphorescent cirri.)
11 56 40	„	From α Cygni, perpendicularly down, to near west-south-west horizon; duration only $\frac{1}{2}''$.
12 0 2 [?=B. $12^h 2^m$]	„	Equal 2nd-mag. star; colourless; crossing Draco, from the direction of Cassiopeia.
13 43 35		Equal 1st-mag. star; from Altair, towards south horizon, with a long blue train.

* Meteors marked thus, B., are regarded as identical with meteors simultaneously observed at Birmingham (see Catalogue); and their real heights are recorded in the Table of Appendix I.

Notes on August Meteors, 1868, *at Winchfield, Hants.*

Time.	Size.	Colour.	Train.	Path.	Remarks as to Train.
August 9th. h m s	Magnitude.				
10 35 0	1st	White	....	From ϵ Pegasi to β Aquilæ.	
11 21 30	2nd	White	....	Vertically downwards from ζ Aquilæ to Scutum Sobieski.	
August 10th.					
10 9 0	= Jupiter	Bluish white	Train	From α Lyræ to α in Ophiuchus.	Train lasted 7 secs.
10 11 0	Jupiter ...	....	....	Along the Milky Way, from its bifurcation.	Train lasted 3 secs.
10 14 0	5th	....	....	To β Equulei.	
10 15 0	4th	....	....	From γ Pegasi towards Jupiter.	
10 16 0	2nd	White	Train	Towards β Aquarii............	Train lasted 2 secs.
10 20 0	4th	White	....	Through head of Aquarius, vertically.	
10 20 40	1st	....	....	From β Aquilæ into Sagittarius.	Passage remarkably swift.
10 22 30	1st	White	....	From near Algenib into Equuleus.	50° in length.
10 35 0	1st	White	Train	Through Milky Way, to β Aquilæ.	
10 35 50	2nd	....	With train...	Near γ and δ Capricorni.	
10 41 10	2nd	....	....	From α Andromedæ to near Jupiter.	
10 46 0 [=B. $10^h 46^m$]	3rd	....	....	From Pegasus, into Delphinus.	
10 48 0	3rd	White	....	West of δ Aquilæ.	
10 51 0	3rd	White	....	Through α Lyræ to γ Lyræ.	
10 51 10	Jupiter ...	Red	Long train...	Through 37 Cygni, in same direction.	
10 53 30	4th	White	With train...	Through the square of Pegasus.	
10 55 10	4th	White	....	From Ophiuchus, downwards from south to south-west.	
10 55 30	4th	White	With train...	From γ and δ Capricorni into horizon.	
11 6 30 [=B. $11^h 7^m$]	Jupiter ...	Bluish white	....	Through Delphinus into south-east.	Train lasted 8 secs.
11 15 0	2nd	White	....	From α to β Aquarii	Train lasted 2 secs.
11 21 0	3rd	White	Short train...	Below Delphinus into Antinous.	
11 26 0	1st	White	....	From Cygnus to Lyra	Train lasted 1 sec.
11 26 50	2nd	....	....	From γ Ursæ Minoris to η Ursæ Majoris.	Train lasted 3 secs.
11 33 0	....	....	Long train...	Transversely parallel to α and β Cygni.	
11 33 10 [?=B. $11^h 33^m$]	1st	White	Long train...	Through γ Draconis, towards β Herculis.	
11 35 0	3rd	White	....	Below Ophiuchus into Antares.	
11 35 30	3rd	White	....	From β Bootis to γ Herculis	Motion slow and reversed, from S. to N.
11 37 50	4th	White	....	From 5 Draconis to β Draconis.	
11 41 50	2nd	Red	....	Through the head of Draco..	Disappeared below Pointers.
11 54 30	1st	White	Train.........	From η of Ursa Major to Acturus.	Described a curve in its course.

TABLE (*continued*).

Time.	Size.	Colour.	Train.	Path.	Remarks as to Train.
August 10th. h m s	Magnitude.				
0 8 30 [=B. 12^h 8^m]	Jupiter ...	White	....	From τ Cassiopeiæ to δ Ursæ Majoris.	Train lasted 3 secs.
0 14 0	4th	White	....	From E. side of Equuleus to Milky Way.	A double meteor, followed instantly by another.
0 17 0	1st	White	....	From θ Draconis to β Bootis	Train lasted 2 secs. (sky now cloudy).
0 22 35	Jupiter ...	Blue	Long train...	From α Draconis to β Bootis	Train lasted 10 seconds.
0 29 10	2nd	White	....	Vertical, from ζ Aquilæ into Scutum Sobieski.	
0 45 0	1st	White	Slight train..	Below α Lyræ to β Aquarii.	
1 1 50	2nd	White	....	In south-west, vertical.	
1 5 50	2nd	White	....	Through little Bear.	
1 22 0	1st	White	Slight train..	From α Cygni, vertically into a cloud.	

Observations discontinued in consequence of cloud and extensive ground-fog supervening.

The observations were made conjointly with Mr. Symons; and only the larger meteors were recorded.

CHARLES H. GRIFFITH.

Stratfield Turgis, Winchfield, Hants.
Lat. 51° 20′ 23″ N., Long. 0^h 4^m 10^s W.

Preliminary Report on Mineral Veins containing Organic Remains in the Carboniferous Limestone. By CHARLES MOORE, *F.G.S.*

FOR several years my attention has been directed to the question of Mineral Veins—to the interesting fact that in many, if not all instances, they contain organic remains, by a study of which it is possible not only to arrive at the probable age of the veins in their several districts, but also, to some extent, the physical conditions associated with them at the time they received their contents.

Thus in the Somersetshire and South-Wales districts, where the mineral veins occur in the Carboniferous Limestone, I have already shown† that they are not older than the age of the Lower Lias. In the case of the Charterhouse Lead-mine this is especially seen to be the case, as 115 species of organic remains of liassic age were obtained from the bottom of this mine, a few of them belonging both to land and freshwater genera, associated, as might be expected, with others belonging to the Carboniferous Limestone itself, within the fissures of which the later material had been deposited.

* Meteors marked thus, B., are regarded as identical with meteors simultaneously observed at Birmingham. See above.

† Quart. Journ. Geol. Soc. 1867, vol. xxiii. p. 492.

As opportunity offered I had been giving an examination to the Carboniferous-Limestone veins of the North of England, in some of which I also detected the presence of a freshwater fauna.

During the past year I have been almost daily occupied in an examination of 134 different samples, derived from the lead-mines of Cumberland and Yorkshire.

The process necessary for the discovery of organic remains is often difficult, and needs much perseverance, a single sample occasionally requiring several days' examination.

The samples selected are from the less mineralized portions of the veins, consisting generally of the "Dowks" or clays. They have therefore to be dissolved and washed, which, from the intractable nature of the material, is often a difficult operation; and the residue is then examined.

From the difficulty involved in a continued examination of many minute organisms, the time has not been sufficient to enable me now to give a detailed account of my investigations, which I propose doing on another occasion; but I proceed to give the general results.

Out of the 134 samples I have examined during the past year, I have found organic remains more or less abundantly in not less than *eighty*—a fact sufficient to show that, as a general rule, they may be found in almost every vein, if a careful examination be given to its contents.

From the investigation of the remains I have obtained from the Cumberland and Yorkshire veins, it is difficult at present to arrive at any precise conclusion (as in the case of the Somersetshire and South-Wales mines) as to when the veins were formed, with the exception perhaps of the Fallowfield Mine in the Tyneside district: all the samples of "dowk" from this mine have very much the character of coal-shales; and from the very interesting fact that I have found specimens of a seed (*Flemingites gracilis*, Carr.) which belongs to the Coal-measures in this mine, there is every reason for fixing the infilling of this vein at the age of the Coal-measures. This mine also yields *Valvata* and *Bythinia*, freshwater univalves, and a bivalve closely related to *Pisidium*.

Amongst the organic remains the chief interest will attach to the presence of *Valvata* and other freshwater shells, often in considerable abundance and in districts wide asunder, showing most conclusively, as I have already pointed out on the Mendips, a connexion between the North-of-England mines and bodies of fresh water, which must have found their way into the veins from some neighbouring land area.

Of vertebrata I have obtained teeth and scales of *Petalodus*, *Ctenoptychius*, *Squaloraia*?, *Saurichthys*?, *Hybodus*?, *Acrodus*? Brachiopoda are represented by *Zellania*, *Thecidium*, *Spirifer*, *Rhynchonella*, *Terebratula*, and *Discina*.

Foraminifera are generally very rare, and in many veins not to be traced. In the Keld-Head mines, however, they are most abundant, especially a *Nummuline-like* form. Altogether, I have obtained five or six genera, including the above and *Nodosaria*, *Cristellaria*, *Dentalina*, *Rotalina*, and also egg-like bodies like single cells of *Nodosaria* or *Dentalina*.

Entomostraca of several species are very widespread, and are probably the most constant organisms, if Encrinital stems are excepted, which are very generally obtained.

Report of a Committee, consisting of General Sir ANDREW S. WAUGH, Sir ARTHUR PHAYRE, General G. BALFOUR, General Sir VINCENT EYRE, Captain SHERARD OSBORN, Mr. GEORGE CAMPBELL, *and* Dr. THOMAS THOMSON, *appointed for the purpose of waiting on the Secretary of State for India to represent the desirability of an Exploration being made of the district between the Brahmaputra, the Upper Irawadi, and the Yang-tse-Kiang, with a view to a route being established between the navigable parts of these rivers.*

AT the Dundee Meeting of the British Association a Committee was appointed to represent to the Secretary of State for India the great importance of an exploration of the country between India and China. Little or nothing has been done for the last thirty years to add to our knowledge of that quite unknown region, though the attention of Government has many times been earnestly called to it by geographers both in India and in England.

The yearly increasing importance of the British Provinces of Assam and Cachar make it from day to day more essential to their prosperity that a communication should, if possible, be opened with China. There are, however, two special reasons why the Committee are desirous of pressing this subject at the present time.

1. Since the establishment of a French colony in Cochin China, there is reason to believe that an exploratory expedition has been investigating the upper course of the Menam. As this course is within Chinese territory, there is no reason to fear any collision between the two expeditions; and it would manifestly be to the advantage of both that they should meet.

2. It has come confidentially to the knowledge of the Committee that an English traveller, well qualified, is about to start from Shanghai for the purpose of exploring the upper course of the Yang-tse-Kiang, and of attempting to reach India. Were a similar attempt made from the Indian side at the same time, his chances of success would be greatly increased.

The provinces of China which are contiguous to Eastern Bengal and Burmah are Se Chuen, which lies on the upper waters of the great river Yang-tse-Kiang, and Yunan, a mountainous province south of Se Chuen, the western parts of which are inhabited by barbarous or only partially civilized races. The road connecting Yunan with Ava through Bamo is pretty well known; and the Committee understand that it is now being carefully examined from the direction of Ava. This route, however, in the opinion of the Committee, is too circuitous to suffice for the wants of Assam, for which province the discovery of a more direct route is most important. There is every reason to believe that the discovery of such, though difficult, is far from impossible.

In many countries this exploration might be left to private enterprise; but there are strong reasons why the task should in Eastern India be undertaken by Government, which alone has the power of influencing the small savage tributary tribes by which Assam is surrounded.

Assam is traversed in its whole length by the river Brahmaputra, which is navigable considerably above Sudiya. The great river Yang-tse-Kiang is believed to be navigable as far as Likiang. Now the distance between these two places in a direct line is less than 255 geographical miles. True the country is known to be very mountainous, and to be traversed by large rivers running through deep gorges, separated by high snowy mountain-chains. These mountains, however, are known to be practicable, as the high road from Lassa, the

capital of Tibet, to China crosses them all just under the meridian of 30°, and enters the water-system of the Yang-tse-Kiang at Bathan. This route is in daily use throughout the summer, but is closed in winter. We may gather from the narrative of Huc that some of the passes are very elevated, and that the country is very difficult for many days' journey. There is this further objection to it, that the direct road from Assam to Eastern Tibet, up the course of the Dihong, is closed to Europeans by savage tribes, who have hitherto resolutely opposed the transit of Europeans through their country. As our influence over these tribes increases, it may be hoped that it will be possible to explore this route.

The great eastern branch of the Brahmaputra, the Lohit, runs through the Mishmi country, a rugged region of steep mountains covered with dense forest. The Mishmis are *de jure*, if not *de facto*, tributary to England. The upper course of this stream is more open and fertile, and inhabited by a Tibetan race, tributary to Lassa. From this province, called Dzain, there are easy passes (closed during winter) N. and E., that to the eastward leading, at a distance of seven laborious days' journey, to the R. C. Mission Station of Bonga, believed to be on the Salween, from which unfortunately the missionaries have recently been expelled. From Bonga, according to these missionaries, there is a practicable route to the eastward.

Further south there is a well-known route, travelled long ago by Wilcox, from Upper Assam to the upper valley of the Irawadi. This route crosses no range more than 9000 feet high, and can therefore present no serious obstacle to commerce. It is, further, in the direct line of nearest contact between the Brahmaputra and the Yang-tse-Kiang. The distance from Sudiya to Mancha, at which place Wilcox struck the Irawadi, is about 100 miles. The unknown part is thus reduced to 155 miles. There is no doubt that this country is mountainous and partly snowy ; but snowy passes are throughout the Himalayas no obstacle to the abundant transit of goods.

The more southerly routes from Assam, over the Patkaye hills and through Munnipore into the valley of the Irawadi, cross no snowy passes, and are most valuable for communication with Burmah; but, as already said, they are too circuitous to suffice for the connexion between Assam and China.

The unknown country the exploration of which is considered essential by the Committee is coloured brown in the sketch map exhibited ; a large part of this area is directly under the control of the Government of India, so that its exploration by a properly equipped party is only a question of expense. The Upper Irawadi and the other regions dependent on Ava are also, it is believed, easily accessible to a British Mission. Whether the obstinate resistance of the Tibetans to the entrance of Europeans is their own act or that of the dominant race can only be known by results. Even if no more can be done, the importance of the thorough investigation of our own and the Burmese provinces cannot be exaggerated. It is only after accurate mapping of the country, and exact determination of the height and steepness of the mountain-chains, that the best route can be chosen. The gain to geographical and natural science would of itself repay all the cost. There is, further, much reason to hope that the gain to commercial interests would be great; and should this not be the case, the urgency of the demand for this exploration by those interests is a good reason for setting the question at rest one way or another.

Report of the Rainfall Committee for the year 1867–68, *consisting of* J. Glaisher, *F.R.S.*, Prof. Phillips, *F.R.S.*, J. F. Bateman, *F.R.S.*, R. W. Mylne, *F.R.S.*, C. Brooke, *F.R.S.*, T. Hawksley, *C.E.*, *and* G. J. Symons, *Secretary.*

Adopting the same arrangement as in former Reports, we have first to record steady progress with the extraction and classification of published and unpublished records, and in the examination of rain-gauges.

The records of the inclined- and tipping-funnelled gauges, described in the Report for 1866, and erected at Rotherham under the superintendence and at the cost of Mr. Chrimes, have been discussed with some care. One of the principal results is the determination of the true angle at which rain fell during certain months, and the effect thereof upon the indications of the gauges.

The following Table shows at a glance the principal results:—

Month.	Recorded Fall.					Per cent. of horizontal.				Mean angle from vertical.	Angle of inclined gauge collecting largest amount.	Rain at 1 ft.=100, rain at 25 ft.=	Mean velocity of wind on days of rain.	Per cent. of increase due to each 1° of tilt to wind.
	Hor.	22½°	45°	67½°	90°	22½°	45°	67½°	90°	° ′	°		miles.	
Jan....	....	....	....	....	....	..	..	..	..	....	....	..	....	....
Feb....	1·688	2·250	2·514	2·408	1·767	133	149	143	105	46 19	45	78	174	1·1
March	1·643	3·050	4·012	5·160	4·405	186	245	314	268	69 33	67½	68	193	3·2
April	2·464	3·057	3·286	2·842	2·178	124	134	115	88	41 28	45	83	211	·7
May..	2·241	2·866	2·947	2·676	1·880	128	132	119	84	40 00	45	90	166	·7
June	1·928	2·263	2·225	1·790	1·093	118	116	93	56	29 33	22½	92	115	·8
July ..	2·184	2·497	2·441	1·920	1·133	114	112	88	52	27 25	22½	91	97	·6
Aug...	3·171	3·314	3·033	2·004	1·007	105	96	63	32	17 29	22½	97	84	·2
Sep....	1·968	2·057	1·908	1·223	·818	105	97	62	42	22 34	22½	93	106	·2
Oct....	1·969	2·314	2·254	1·808	1·136	118	114	92	58	29 59	22½	88	105	·8
Nov...	·691	·817	·829	·697	·441	118	120	101	64	32 33	45	86	153	·5
Dec...	1·353	2·241	2·664	3·027	2·370	166	197	224	175	60 17	67½	81	164	1·8
Totals	21·300	26·726	28·113	25·555	18·228	..	..	..	..	40 37	....	..	....	1·0

which may be thus briefly enumerated.

1. There is no month in the year in which a gauge whose mouth is horizontal collects so much as one which is inclined and kept face to wind by a vane.

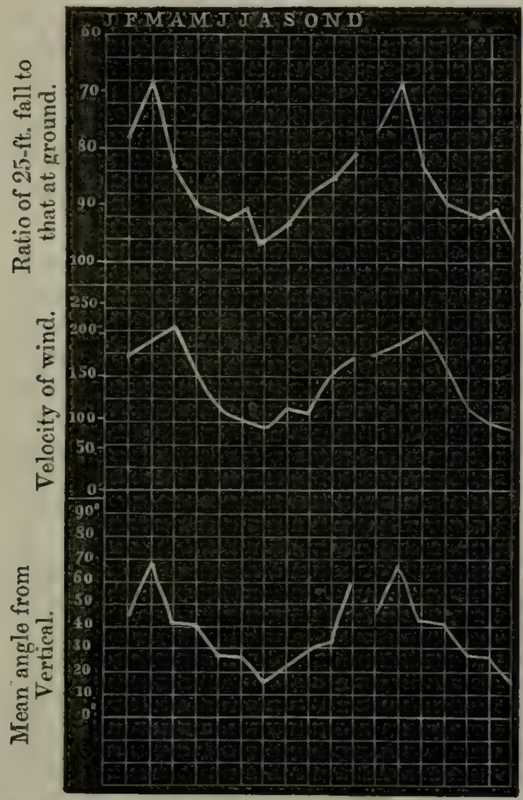
2. In summer, rain falls nearly vertical, the average angle therewith being about 20°, in spring and autumn about 45°, and in winter more than 60°.

3. The ratio of the fall on the ground to that at 25 ft. above it bears a nearly constant relation to the angle of fall; for instance, in two months, when rain fell at a mean angle of 65° from the vertical, the 25-feet gauge collected 25 per cent. less than that on the ground; and, on the other hand, in two months when the mean angle was 20°, the upper and lower gauges only differed by 5 per cent.

4. The relation of these results to their cause-wind is shown in the an-

nexed diagram; and the accordance would doubtless have been still more striking had the velocity during the time of rain been recorded instead of the total motion in 24 hours.

Fig. 1.



5. The necessity of all observers keeping the top of their gauges strictly level is brought out very clearly by these Tables; they show that in summer a tilt of even 1° will cause a difference of 0·2 per cent. in the amount collected, and in winter of 2 or 3 per cent. It is not infrequent to find gauges 2° or 3° from level, which would give a total error of 5 per cent. *if* they were always inclined towards the wind; but as the errors are never intentional, it is probable they neutralize one another; but it would be far better for observers to be careful to keep the orifices level, and so avoid the error altogether.

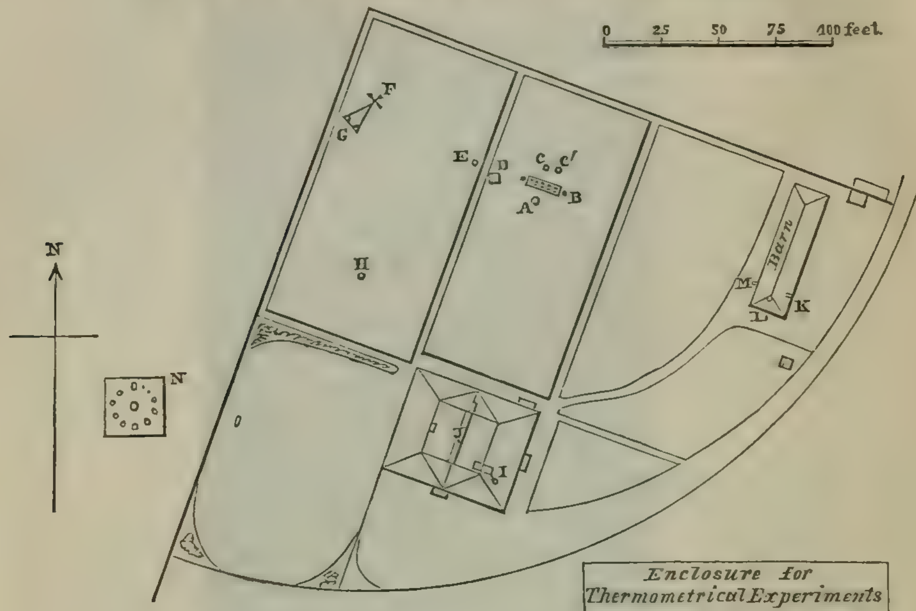
We mentioned last year that Professor Phillips had promised to examine these records; this he has not been able to complete, but he hopes to do so during the coming year.

The gauges constructed for Colonel Ward of Calne, in the year 1863, for the purpose of determining (1) the ratio of decrease of rainfall with elevation above the ground, and (2) the relative amount collected by gauges of different sizes and forms, and observed by him during the years 1863–1867 have, in consequence of his ill health and removal from Calne, been moved during the past year to the Rectory grounds, Stratfield Turgis, Winchfield, Hants, where they have been placed under the care of the Rev. C. H. Griffith, an experienced and very accurate observer.

The Rectory is at a height of 200 feet above the mean sea-level, in lat. 51° 20′ 23″ N., and long. $0^h\ 4^m\ 10^s$ W.; a space of 32 acres, with no tree more

than 10 feet high, and very few more than 6 feet, surrounds the house. The whole of the grounds are perfectly level, as is also the surrounding land for nearly half a mile in all directions. The following ground-plan shows the

Fig. 2. Plan of Grounds of Stratfield Turgis Rectory.



EXPLANATION.

A. Crallan's ground-gauge.
B. Material-series of gauges.
c c'. 8-in. monthly and daily gauges.
D. Thermometer-stand.
E. 5-in. gauge 3 ft. high.
F. Robinson's anemometer.
G. 8-in. and 5-in. gauges 20 ft. high.
H. Intermediate 8-in. gauge.
I. 8-in. bracket gauge 39 ft. high.
J. 8-in. roof-centre gauge 29 ft. high.
K. 8-in. barn gauge 16 ft. high.
L. 8-in. barn gauge 23 ft. high.
M. 8-in. barn gauge 11 ft. high.
N. Magnitude-series of gauges.

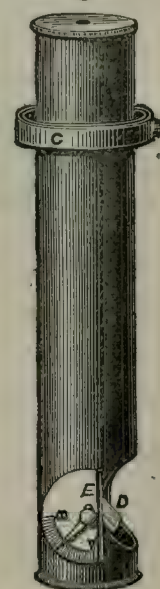
positions of the various instruments. It may be well to explain that in December, 1867, Mr. Symons transferred to Mr. Griffith a series of fourteen gauges which had been constructed with a view to testing several questions as to the best material for the funnels of rain-gauges, the loss from evaporation under various conditions, the influence of the angle of the rim of the gauge, and some other points. On notice of Colonel Ward's intended removal being received, the extent to which the objects originally contemplated had been attained was considered. It was thought that the four years' observations at Calne, corroborated as they were by two years at Castleton Moor, and current observations at Rotherham had sufficiently indicated the law of decrease of rain, out of the influence of buildings; it was therefore resolved that three only of the elevation gauges should be remounted in their old form, and that the rest of them should be placed on the roof of the Rectory and outbuildings, in such positions as to give some indication of the influence of, and amount of error due to, various positions of roof gauges.

Professor Phillips, F.R.S., and Mr. Symons have both, independently, been investigating the relation between height above sea-level and amount of rainfall as indicated by both new and old stations in the Cumberland district. Professor Phillips's paper appeared in the Proceedings of the Ashmolean So-

ciety, and seems to us of such importance that we have transferred it to the Appendix to this Report. Professor Phillips found that in the Scawfell group the maximum fall was at an altitude of 1463 feet; Mr. Symons*, by an entirely different method, had determined that the maximum was at an altitude of 1000 to 1500 feet; the two methods, therefore, have led to somewhat similar results.

The examination of rain-gauges has been continued as opportunity offered, and on exactly the same plan as previously, except that a small instrument termed an "altameter" has been designed by Mr. Symons for his own use in determining the angle of elevation of trees, buildings, &c. above rain-gauges, and therefrom the suitability of the position in which the gauge may have been placed. "It consists of a brass tube 6 inches long and three-quarters of an inch in diameter; near the top are double gimbals (C), by the outermost of which the instrument is suspended between the fingers, when, of course, the body assumes a truly vertical position. At the lower end is a small mirror (D), turning on a horizontal axle, whereof one end is prolonged at E, and carries a pointer on the graduated arc (A B). If the mirror is (as represented) at an angle of 45°, objects level with the mirror will be seen in its middle, by looking through the small eye-hole at the top; but if objects are above its level, the mirror must be turned by the axle (E) into a more horizontal position; and when the objects are seen crossing the centre of the mirror, the index will be found as many degrees towards A as the objects are above the instrument."

Fig. 3.



In our last Report to this Association, attention was drawn briefly to the variations in the proportion of the mean annual rainfall which is measured in the different calendar months; and a Table was given, from which it appeared that, at stations south of the Tweed, the principal part of the rainfall occurs in summer where the total fall is small, and in winter where it is large. But the data used in preparing that Table extended over a period of only ten years; a hope was therefore expressed that during the ensuing year a full investigation might be made, and some further light thrown on the subject.

This has now to some extent been done—though, as in all meteorological investigations, the further search has discovered fresh difficulties and complications, many of which must stand over for future discussion. The following, however, is a brief account of the steps which have been taken, and the results attained since the last Report.

The mean annual and monthly rainfall for all available stations in each decennial period since the year 1730 were first calculated and tabulated, the stations being arranged alphabetically for easy reference; this involved the extraction of nearly 40,000 monthly readings. From these figures the values for monthly percentage of the annual fall were calculated † and tabulated in a similar manner, together with the actual mean annual fall for each station during each decennial period.

As the Table given last year seemed to show that the time of the maximum monthly fall varies with the total amount registered in the year,

* British Rainfall, 1867.

† By F. Gaster, Esq., F.M.S., who has also drawn up the following abstract of the results he has obtained.

and since, as a rule, the greatest quantity of rain falls at our western stations, and the least at the more eastern ones, it seemed probable that the peculiarity of a maximum fall in winter might be general in the west and a maximum in summer in the east. With a view to the determination of this question, the whole of the stations were grouped in their respective counties, and these were arranged in districts. The districts chosen were the following:—

Countries.	Districts.
England and Wales	3: Western, Central, and Eastern.
Scotland	2: Western and Eastern.
Ireland	Not divided, returns too few.

In cases where one county has properly formed part of two districts it has been divided, and the stations distinguished by being arranged in the portion to which they belong. Thus Yorkshire is divided into east and west Yorks.

It is impossible to give here all the Tables which have been prepared, as they occupy far too large a space; but the following list of stations in Lancashire (1850–59) abundantly proves that the supposed law of westerly maximum in winter and easterly in summer does not actually exist.

Table I.—Monthly Percentage of Annual Rainfall, Lancashire, 1850–59.

Name of Station.	Mean Annual Rainfall in the period.	Monthly percentage of Annual Fall.											
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	in.												
Belmont	51·190	9·4	7·7	6·1	5·9	4·9	8·1	8·8	11·1	8·3	10·3	9·2	10·2
Bolton	44·006	9·3	8·3	5·9	5·8	5·1	8·6	9·1	9·8	8·5	10·3	9·5	9·8
Coniston	71·400	13·2	9·2	6·2	5·5	4·1	6·6	6·7	9·4	7·3	9·9	9·1	12·8
Fishwick	29·103	9·0	6·1	5·3	5·0	5·7	8·9	11·2	12·0	9·3	10·9	8·0	8·6
Holker..........	39·167	10·7	7·4	5·8	6·0	4·4	8·8	9·4	10·5	8·4	10·4	8·4	9·8
Howick, Preston..	34·279	9·3	6·9	5·6	5·6	4·9	8·9	10·6	11·2	9·6	9·5	8·2	9·7
Liverpool Observy	24·339	7·1	5·0	5·6	6·1	6·1	10·1	11·8	11·7	9·3	11·5	8·9	6·8
Preston, 1 ft.	33·601	9·2	6·5	5·5	5·5	5·2	9·1	10·9	11·8	9·4	10·2	8·1	8·6
Ditto, 53 ft.	28·932	8·6	5·9	5·3	5·3	5·5	9·4	11·2	12·6	9·5	10·4	8·0	8·3
Rufford	33·237	8·7	6·0	5·3	5·5	5·3	9·1	11·2	11·4	8 9	11·3	8·7	8·6
Stonyhurst	45·368	9·3	8·4	5·7	5·6	4·5	9·5	9·3	10·4	9·1	10·8	7·9	9·5
Wray Castle	60·807	13·9	9·1	5·8	5·5	4·3	6·4	7·4	9·1	7·0	10·2	8·7	12·6

The values in the above columns represent the percentage of the mean annual fall which was registered in each month. The quotation only fairly typifies what is found in all counties where the annual rainfall varies considerably. It will be seen we have in this one western county some stations with their maximum in the summer, others with theirs in the winter, and others with theirs in the autumn—and this during precisely the same period of time.

It was therefore deemed advisable to return to the original plan of grouping the stations according to the amount of their annual fall, for each 5 in. of depth—but with this distinction, that a separate set of Tables was prepared for each of the districts into which we have hypothetically divided the Kingdom.

For dates before the year 1830, the number of returns available is too

small* to give very reliable values; so that only the records for the periods since that date were made use of. The following Tables contain the results of this grouping for each decennial period. The first column gives the limiting amounts for the groups; the second, the name of the district; the third, the number of stations represented in that district, from which the mean percentage values (which follow in the other columns) have been obtained. It has been thought better also to bring together the groups of *equal* value in each district for the sake of intercomparing the results.

Table II.—England and Wales.

Monthly percentage of Annual Rainfall.

(Mean Values. Stations arranged in 5-in. groups according to their annual fall.)

Limiting Amounts.	Name of District.	Number of stations.	Monthly percentage of Annual Fall.											
			Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
			Decennial Period 1830–39.											
in. in.														
15–20	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	*1.	5·5	6·4	4·6	6·8	7·1	11·1	10·6	9·8	11·4	10·3	9·9	6·5
20–25	W.	1.	7·1	6·5	6·2	5·2	6·6	11·0	11·2	9·8	8·8	9·5	10·0	8·1
	C.	2.	5·2	7·5	6·4	6·9	6·6	9·9	10·7	8·7	11·5	9·4	10·5	6·7
	E.	7.	6·5	7·9	6·3	6·8	6·4	10·1	8·7	9·5	10·4	10·2	9·8	7·4
25–30	W.	2.	7·0	8·0	6·4	6·0	4·7	10·2	8·1	7·7	8·5	10·1	13·6	9·7
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	3.	6·9	8·1	6·6	6·4	5·7	10·5	9·7	9·5	9·1	9·1	10·5	7·9
30–35	W.	6.	6·7	7·8	7·1	5·8	4·7	9·7	9·1	8·2	8·8	9·9	12·8	9·4
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	0.	...	...	...	...	...	...	...	...	...	...	...	...
35–40	W.	2.	6·1	7·3	7·3	5·7	4·3	9·9	10·1	8·7	9·4	9·7	11·9	9·6
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	0.	...	...	...	...	...	...	...	...	...	...	...	...
40–45	W.	1.	7·0	8·0	7·8	5·8	4·4	8·8	8·9	8·7	9·2	9·5	12·5	9·4
55–60	W.	1.	7·2	9·4	8·1	4·5	2·9	8·2	9·5	8·1	9·5	10·2	11·5	10·9
			Decennial Period 1840–49.											
15–20	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	1.	6·6	4·8	5·1	6·6	10·5	9·0	9·7	10·0	9·5	13·6	7·8	6·8
20–25	W.	2.	8·2	7·1	5·7	7·0	7·1	8·8	9·6	10·0	8·3	11·2	10·1	6·9
	C.	1.	7·2	7·0	5·5	6·3	8·4	8·2	7·8	9·9	11·2	11·9	9·9	6·7
	E.	8.	7·0	6·2	5·9	6·7	9·0	7·5	9·6	10·6	9·2	12·7	9·4	6·2
25–30	W.	3.	8·2	6·6	6·1	6·2	7·4	7·7	8·6	9·8	9·5	11·4	11·2	7·3
	C.	4.	8·0	7·4	6·2	6·6	7·6	7·7	7·7	10·0	9·6	11·7	10·4	7·1
	E.	7.	7·8	6·8	6·0	6·1	8·0	7·8	9·7	9·9	8·9	12·4	9·9	6·7

* A large number of registers are useless in the *present* investigation, because they do not contain complete records during either of the decennial periods. Thus a register from 1832 to 1847, although containing sixteen years' observations, must be put on one side, since neither of the periods 1830–39 or 1840–49 is fully represented.

TABLE II. (*continued*).

Limiting Amounts.	Name of District.	Number of stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
30–35	W.	4.	9·4	7·0	6·6	6·7	6·9	7·3	8·5	8·7	8·8	11·0	11·3	7·8
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	1.	9·5	8·3	5·7	5·4	6·8	5·7	7·1	9·5	9·4	12·4	12·1	8·1
35–40	W.	2.	8·9	6·8	6·6	6·0	6·7	7·6	9·0	9·5	8·5	11·5	11·2	7·7
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	1.	10·0	8·2	5·5	5·6	6·7	5·9	7·4	9·5	8·5	11·9	13·4	7·4
40–45	W.	6.	9·7	7·5	7·0	6·2	6·2	6·8	8·1	8·6	8·3	10·7	11·6	9·3
45–50	W.	1.	9·6	6·6	6·0	5·0	6·1	7·4	10·6	10·4	8·6	11·3	10·0	8·4
50–55	W.	2.	9·8	7·3	7·3	5·4	5·2	7·3	9·1	8·5	7·4	11·9	11·5	9·3
55–60	W.	1.	9·7	8·5	6·5	6·0	6·4	6·7	7·1	7·8	8·1	10·6	13·9	8·7
70–75	W.	1.	10·6	7·6	7·4	5·0	4·9	6·3	8·4	8·6	6·6	12·8	12·0	9·8
			DECENNIAL PERIOD 1850–59.											
15–20	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	C.	1.	7·7	4·5	4·8	7·0	6·2	11·1	11·8	13·2	8·6	11·1	8·3	5·7
	E.	4.	7·7	4·7	5·3	6·9	7·4	8·7	12·3	11·8	9·3	10·7	8·9	6·3
20–25	W.	8.	7·9	5·5	5·7	7·2	7·0	10·2	10·6	10·5	9·1	11·1	8·5	6·7
	C.	9.	8·5	4·4	5·0	7·0	7·8	9·4	11·7	10·6	9·0	11·9	8·3	6·4
	E.	12.	7·9	4·8	5·1	7·1	8·5	8·2	12·1	10·4	9·0	12·3	8·6	6·0
25–30	W.	11.	9·1	5·4	5·5	6·9	7·2	9·0	9·9	9·8	8·4	11·7	8·5	8·6
	C.	7.	8·8	4·5	5·3	7·6	8·0	8·6	9·6	9·5	9·0	13·3	8·5	7·3
	E.	12.	8·7	4·8	5·3	7·0	7·5	7·3	11·0	9·6	9·5	12·7	9·5	7·1
30–35	W.	9.	9·3	6·1	5·7	7·2	6·3	8·4	8·7	9·4	8·7	11·7	9·3	9·2
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	2.	9·7	4·2	5·5	6·9	7·6	7·6	8·7	8·1	10·0	14·9	8·9	7·9
35–40	W.	5.	10·4	6·9	6·6	7·0	5·8	8·5	8·1	9·0	7·9	11·3	9·0	9·5
	C.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	1.	9·7	4·5	6·8	6·7	7·0	7·8	9·4	7·8	10·1	14·3	8·2	7·7
40–45	W.	4.	11·4	7·4	6·5	6·9	5·8	7·7	7·7	8·6	7·6	10·9	9·2	10·3
45–50	W.	2.	9·3	7·7	5·3	5·6	4·8	9·4	9·4	10·9	8·7	10·9	8·8	9·2
50–55	W.	2.	10·7	7·1	6·4	7·3	5·8	7·7	7·7	9·2	8·0	10·6	9·3	10·2
55–60	W.	1.	13·9	7·8	5·7	4·9	4·8	7·0	7·7	8·1	8·4	10·7	8·5	12·5
60–65	W.	1.	13·9	9·1	5·8	5·5	4·3	6·4	7·4	9·1	7·0	10·2	8·7	12·6
65–70	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
70–75	W.	2.	14·1	9·6	6·0	5·5	4·0	6·4	6·8	9·0	7·2	9·8	8·9	12·7
125–130	W.	1.	13·6	9·6	6·4	6·0	4·5	6·8	7·2	8·5	7·2	10·2	8·1	11·9

* This gauge is 60 ft. above the ground.

TABLE II *a*.—SCOTLAND. Monthly percentage of Annual Rainfall.

(Mean Values. Stations arranged in 5-in. groups according to their annual fall.)

Limiting Amounts.	Name of District.	Number of stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
in. in.			DECENNIAL PERIOD 1830–39.											
15–20	W.	0.	...	...	...	..	...	...	...	...	...	...	...	...
	E.	1.	4·6	4·5	6·6	6·9	5·7	8·3	8·9	9·5	12·9	11·3	12·0	8·8
20–25	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	1.	6·0	6·2	6·4	5·9	5·7	11·1	10·6	11·4	11·9	8·2	8·8	7·8
25–30	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	5.	7·2	7·1	7·9	5·9	4·9	8·0	9·0	9·1	10·8	9·9	10·7	9·5
30–35	W.	2.	7·1	8·2	8·1	5·4	4·0	6·8	7·8	8·6	10·8	10·4	12·5	10·3
35–40	W.	2.	6·6	6·8	7·7	4·8	4·8	7·9	9·6	8·1	9·9	10·7	12·5	11·6
50–55	W.	1.	7·1	8·5	9·0	5·2	5·1	6·4	8·0	7·7	10·2	10·3	10·8	11·7
			DECENNIAL PERIOD 1840–49.											
20–25	W.	1.	10·4	7·1	6·0	4·8	5·4	6·9	9·1	11·7	7·5	12·4	11·2	7·5
	E.	6.	7·5	7·0	5·6	5·0	7·5	9·6	10·9	10·3	8·0	12·3	9·6	6·7
25–30	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	6.	9·7	7·3	6·1	5·0	6·1	7·7	8·6	9·5	7·8	12·8	10·5	8·9
30–35	W.	4.	9·8	7·4	6·9	5·6	5·4	7·6	9·5	9·3	7·5	11·5	10·9	8·6
	E.	2.	9·2	7·8	6·3	4·5	6·9	8·9	10·6	9·7	6·7	11·1	10·6	7·7
35–40	W.	2.	11·3	7·5	6·8	5·0	5·1	6·6	8·4	8·8	6·9	12·2	11·7	9·7
	E.	1.	9·8	9·3	6·7	4·8	6·1	8·3	10·3	9·4	6·2	10·7	10·2	8·2
40–45	W.	1.	11·6	8·1	6·8	5·1	5·5	7·2	9·6	8·1	7·8	10·7	11·4	8·1
	E.	2.	10·0	8·9	7·1	4·8	6·0	8·2	9·8	9·5	6·5	10·4	10·7	8·1
45–50	W.	1.	10·2	7·3	6·9	5·8	5·9	7·5	10·2	9·1	8·2	10·6	10·9	7·4
	E.	0	...	...	...	...	...	...	...	...	...	...	...	...
			DECENNIAL PERIOD 1850–59.											
15–20	W.	0.	...	...	...	...	...	...	...	...	...	...	...	...
	E.	3.	8·4	5·4	5·4	7·1	5·5	8·2	9·2	10·9	8·6	11·8	9·9	9·6
20–25	W.	1.	10·9	8·2	6·2	7·4	4·8	9·0	9·4	7·3	5·1	10·8	9·4	11·5
	E.	10.	9·9	6·4	5·5	5·8	5·4	8·6	9·4	9·3	8·1	12·4	9·5	9·7
25–30	W.	*1.	11·4	7·8	5·7	5·3	6·3	9·4	10·1	9·4	8·1	10·1	6·4	8·0
	E.	7.	10·7	6·8	6·2	6·3	5·5	8·7	9·1	9·6	7·3	10·9	9·1	9·8
30–35	W.	3.	11·0	8·3	6·7	5·9	4·6	6·7	8·9	8·5	8·1	10·3	9·4	11·6
	E.	5.	10·9	6·6	7·1	6·8	6·2	8·3	8·2	8·6	8·3	10·2	9·9	8·9
35–40	W.	4.	11·1	7·6	6·6	5·5	4·9	8·0	9·2	8·4	7·5	10·9	8·9	11·4
	E.	4.	12·2	7·8	6·5	5·7	5·0	7·4	8·0	8·7	7·3	11·3	9·1	11·0
40–45	W.	2.	11·0	8·2	6·3	7·8	5·5	8·5	8·2	9·5	6·5	9·5	8·6	10·4
	E.	*1.	10·2	8·0	5·0	4·8	6·2	8·8	11·2	10·6	7·3	10·1	6·3	11·5
45–50	W.	2.	10·5	8·6	6·9	6·8	5·7	8·5	8·5	9·2	6·6	9·9	7·7	11·1
50–55	W.	1.	11·7	7·9	6·4	5·7	5·4	6·5	9·2	8·7	7·3	10·4	8·2	12·6
65–70	W.	1.	13·0	9·2	6·9	6·4	5·0	6·6	7·4	7·8	6·7	10·1	7·7	13·2
70–75	W.	1.	14·4	9·3	6·6	4·9	4·0	5·4	6·9	6·1	8·0	10·1	9·5	14·8

* The returns from these stations seem very singular!

TABLE II *b*.—IRELAND.

Monthly percentage of Annual Rainfall.

(Mean Values. Stations arranged in 5-in. groups according to their annual fall.)

[Returns before 1840 too few for use in this manner.]

Limiting Amounts.	Name of District.	Number of stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
			DECENNIAL PERIOD 1840–49.											
20–25	*	1.	7·7	6·2	5·2	6·9	8·2	7·8	8·6	11·2	8·1	12·3	10·1	7·7
25–30	...	2.	9·2	6·8	6·4	6·9	7·4	6·8	9·1	9·6	7·7	11·1	10·9	8·1
30–35	...	1.	10·1	7·7	7·3	6·2	6·2	8·2	9·0	8·1	7·4	10·5	10·4	8·9
35–40	...	1.	9·4	7·4	5·6	7·0	5·9	7·1	9·4	9·8	7·7	12·4	9·7	8·6
			DECENNIAL PERIOD 1850–59.											
20–25	...	2.	9·3	5·5	6·2	7·9	8·1	10·3	9·0	8·4	8·0	9·6	9·7	8·0
25–30	...	2.	9·8	5·3	6·0	8·8	8·0	9·8	9·6	7·7	7·9	9·6	8·7	8·8
30–35	...	2.	11·5	8·0	6·7	8·1	6·0	7·7	8·5	9·2	7·2	8·5	8·4	10·2
35–40	...	3.	11·2	6·9	6·8	7·5	6·3	8·4	8·2	8·9	7·4	9·2	8·6	10·6

* The number of stations in Ireland is so small, that their arrangement into districts has not been attempted.

England and Wales.—During the first two of these decennial periods (Table II.) the returns are not very numerous; so that the effect of this grouping is scarcely so manifest as in the period 1850–59. In the period 1830–39, only one return is available for the group "55 to 60 in.," and none at all for higher amounts. Nevertheless a comparison of the values from that station with those from the "20 to 25-in." group shows decidedly the tendency to a winter maximum in the former, and a summer maximum in the latter. In looking down the tabulations for 1840–49 and 1850–59, the gradual drawing of the larger percentages from the middle to the right-hand columns as the annual fall in each district increases, is evident at a glance; and in the groups for the *highest* amounts, the maximum is found to have passed on to the January column, and at some places even the February value is *much* increased.

It is much to be regretted that the rain-gauges were so unevenly distributed over the country that it is almost useless to attempt the intercomparison of groups of similar value in the different districts. There appears, however, at first sight reason for believing that, in groups of the same actual annual rainfall, the maximum monthly proportion occurs rather later in the year in the eastern districts than in the western.

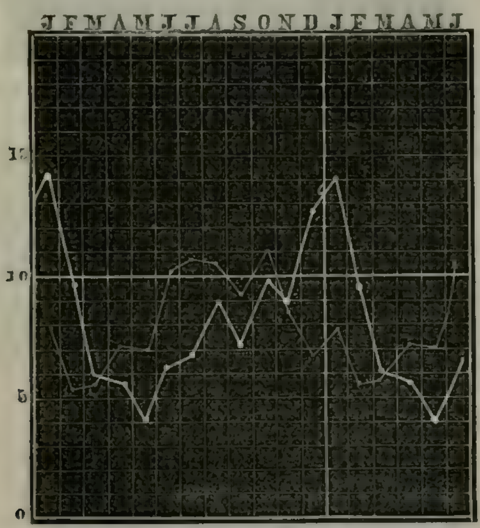
Another peculiarity shown by these Tables is this; the period of minimum monthly fall also advances to a later period of the year the greater the annual rainfall, though to a less extent than the maximum. In places where the fall is small, the minimum is usually found in February or March, whilst in

those where it is large the minimum is in May. The deficit of two or three days in February should be allowed for, and we shall then find the true minimum is usually in March, especially as that month contains thirty-one days.

One more feature is to be noticed; for it is impossible in the limited space which is here available to do more than *point out* the *principal* peculiarities in so large a work. It is this:—at stations where the annual rainfall is large, the maximum monthly fall is a more decided maximum, and the minimum a more decided minimum than at stations where the amount is small—in fact the greater the total yearly fall the greater the monthly range.

The above statements will be rendered more clear by the following diagram (fig. 4), in which the curves for the 20 to 25-in. and 70 to 75-in. groups for the period 1850–59 are shown. This particular period is chosen because the larger number of returns give more satisfactorily the variations which, however, are *clearly* discernible in all the periods yet examined.

Fig. 4. England and Wales. (Western District.)



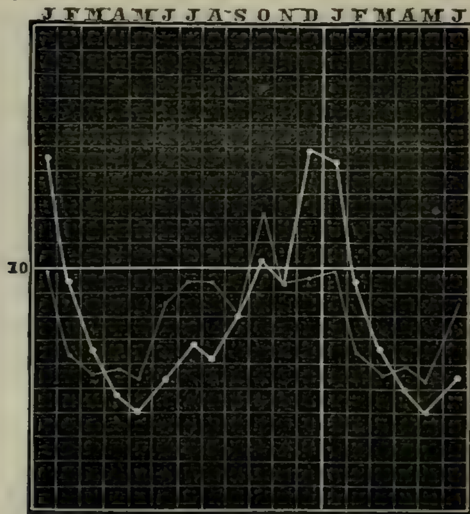
(N.B. The 70 to 75-in. curve has been chosen in preference to the (exceptional) 125 to 130-in., as it is obtained from more than one station, and may be better compared with other returns.)

The first six months of the year are repeated after December, in order that the complete curve for all parts of the year may be seen more readily.

Scotland.—In considering the registers from the Scotch stations (Table II*a*.), we are obliged to speak with some reserve, as the number of reports received from that country for the period under discussion is very small. During 1830–39, the first three groups are represented only in the eastern, and the last three only in the western districts.

In those cases alone where the number of reports is insufficient to furnish reliable mean values, is a summer maximum shown at all; the tendency is to an *autumnal* excess at stations with small annual falls. The winter maximum at wet stations is, however, very decided. In the following diagram (fig. 5) the "20 to 25-in." curve for the *eastern* district, and the "70 to 75-in." curve for the *western* (1850–59) are shown. Although the latter is obtained from but one station, it agrees so well with the other higher groups, that it may be presumed to represent very approximately the true average.

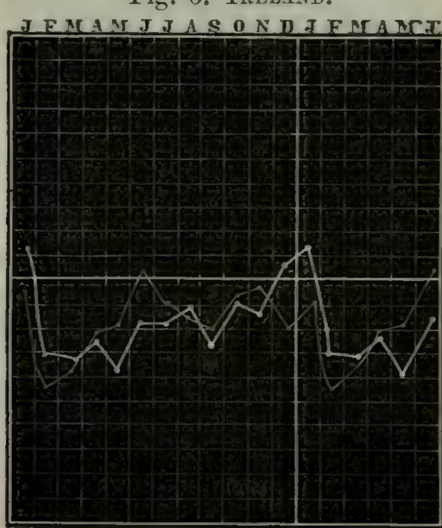
Fig. 5. Scotland. (Eastern curve 20 to 25 in.; western curve 70 to 75 in.)



The variation in the minimum monthly value (if there is any variation at all) cannot be well determined from the Tables.

Ireland.—The returns from Ireland are still fewer than those from Scotland, and the range in the values of the mean annual falls is very limited. Still the prevalence of a slight summer maximum and February minimum at the station with little rain, but a winter maximum and May minimum at those with little rain is traceable—though with far less distinctness than the corresponding extremes in either the Scotch or English tabulations. The following diagram (fig. 6) gives the "20 to 25-in." and "35 to 40-in." curves for the period 1850–59.

Fig. 6. Ireland.



To recapitulate briefly, we find that in England and Wales the following rules are generally observed in the distribution of rain during the different months of the year:—

* "*First.*—If we take an average of a considerable number of years of the rainfall at various stations, we find that not only do the mean annual amounts vary, but the monthly percentages of those amounts also vary considerably.

* British Rainfall, 1867.

"*Secondly.*—That (with some exceptions) the time of year when the maximum monthly amount occurs, changes with the variations in the mean annual rainfall; stations where little falls having their maximum in summer, but those where the fall is large having theirs in the winter months.

"*Thirdly.*—That, so far as the present investigation has proceeded, these laws hold good in all three districts into which we have supposed England and Wales to be divided.

"*Fourthly.*—That at stations where the rainfall is very large, the minimum monthly fall occurs about two months later in the year, and the maximum about six months later than at those of small amount; and that in the former case, these periods of extremes are more clearly defined than in the latter."

In Scotland a summer maximum is not generally found, but an autumn preponderance is noticed at the drier stations, and a very decided winter maximum at the wet stations. The month of minimum does not appear to vary much.

In Ireland the returns are not sufficiently numerous to give very reliable results.

It will be seen from the foregoing remarks, that not at *all* the stations are these rules observable; were it so, a small number of returns would suffice to show them as well as a large. But the exceptions are few, and may be often arranged in groups—thus giving hope of discovering the causes of the changes we have been speaking of. This, however, is a part of the work which at present has scarcely been entered on, and it would be premature to attempt assigning any reasons for the phenomena we are noticing until they have been more thoroughly and minutely examined. That there are more causes than one seems certain.

An attempt has been made to discover whether the same relative monthly values are found at the same station in all decennial periods; but very little has yet been done in this direction, though it is hoped it will be completed in the forthcoming year. It is likely that averages of a larger number of years than ten will give more satisfactory results than the present decennial arrangement; but this, too, must be left for the future to prove. A correction will be necessary for the height of gauges above ground when the work of more minute examination commences, as that to some extent affects the monthly values.

The whole investigation must be considered as still in its infancy, and some modification of the views here stated may be requisite as we advance. It seems, however, scarcely right to withhold what is so apparent, because we are not acquainted with *every* particular we wish for. Rather, should the publication of what is here offered, with a caution as to its being *too* freely depended on, either excite wholesome criticism, or in any way stimulate the work of collecting and properly examining rainfall records, much good will have been done to this branch of Meteorology. Meanwhile no pains must be spared in conducting, if possible, to a successful issue, the present investigation into the monthly distribution of rain over these Islands.

Some preliminary steps have been taken towards approximately determining the correction applicable to such of the returns previously referred to as have been obtained from gauges at any height above the ground. It is known to many persons that the deficient amount of rain collected in gauges elevated above the ground varies with the time of year. Of course if the deficiency was constant, the monthly falls would bear the same relation to one another as if the gauge had been placed on the ground; but this is not the case; the deficiency is not uniformly distributed throughout the year,

but is far greater in winter than in summer, and therefore the result of attempting to deduce the relative fall in different months from elevated gauges *must* fail, unless we can determine the correction required. This we have essayed to do by examining the results of the various gauges at different heights at the Royal Observatory Greenwich, as well as the experimental sets at Calne, Rotherham, &c. The results are embodied in the three following Tables. The construction and mode of using of these Tables is so obvious as to require no explanation beyond the headings of the columns and the examples given. It should, however, be mentioned that the values herein given are not assumed as perfectly correct, but rather as types of more detailed ones to be subsequently compiled.

Greenwich, 1862–65.

Totals and per cent. of Ground Fall.

	Ground gauge.	10 feet.		22 feet.		38 feet.		51 feet.	
Year.	Amount.	Amount.	Per cent. of ground fall.	Amount.	Per cent. of ground fall.	Amount.	Per cent. of ground fall.	Amount.	Per cent. of ground fall.
January	8·70	8·52	98	6·48	74	6·14	71	4·98	57
February	3·51	3·18	91	2·70	77	2·21	63	1·72	49
March	7·58	7·52	99	6·23	82	5·39	71	4·33	57
April	4·42	4·40	100	3·86	87	3·51	79	2·91	66
May	10·47	10·35	99	9·37	90	8·53	81	7·18	69
June	9·17	9·03	98	7·75	84	7·61	83	6·66	73
July	5·14	4·96	96	4·34	84	4·34	84	3·57	69
August	10·08	9·83	98	8·93	88	8·43	84	6·86	68
September	7·52	7·41	98	6·13	81	6·16	82	5·36	71
October	12·86	12·43	97	10·55	82	9·76	76	8·36	65
November	7·56	7·16	95	5·32	70	5·22	69	4·30	57
December	4·07	3·87	95	2·65	65	2·37	58	1·89	46
Means	......	...	97·0	...	80·3	...	75·1	...	62·3

	Calne.			Rotherham.						
	1 foot.	20 feet.		1 foot.	10 feet.		20 feet.		25 feet.	
Year.	Amount	Amount	Per cent	Amount	Amount	Per cent	Amount	Per cent	Amount	Per cent
January	3·36	3·00	89	...	...	...	...	...	...	...
February	1·95	1·70	87	1·88	1·63	87	1·56	83	1·45	78
March	3·27	2·79	85	1·90	1·38	73	1·28	68	1·28	68
April	3·23	2·93	91	2·70	2·39	89	2·32	86	2·20	82
May	1·79	1·74	97	2·43	2·20	91	2·16	89	2·18	90
June	2·19	2·11	96	2·02	1·88	93	1·87	93	1·84	91
July	3·68	3·60	98	2·27	2·13	94	2·09	92	2·06	91
August	3·02	2·96	98	3·22	3·14	98	3·09	96	3·11	97
September	1·79	1·71	96	2·03	1·92	95	1·89	93	1·89	93
October	2·86	2·72	95	2·08	1·90	91	1·86	89	1·83	88
November	1·27	1·19	94	·74	·67	90	·64	86	·63	85
December	1·67	1·53	92	1·53	1·31	86	1·28	84	1·25	81
Means	...	...	93·0	...	...	89·7	...	87·2	...	85·8

Altitude Correction.

Factors to be multiplied into the mean annual correction.

	Greenwich.				Calne.	Rotherham.		
Year.	10 ft.	22 ft.	38 ft.	51 ft.	20 ft.	10 ft.	20 ft.	25 ft.
January	1·01	·92	·94	·91	·96	...	...	...
February	·94	·96	·84	·79	·94	·97	·95	·91
March	1·02	1·02	·94	·91	·91	·81	·78	·79
April	1·03	1·08	1·05	1·06	·98	·99	·99	·96
May	1·02	1·12	1·08	1·11	1·04	1·01	1·02	1·05
June	1·01	1·05	1·10	1·17	1·03	1·04	1·07	1·06
July	·99	1·05	1·12	1·11	1·05	1·05	1·06	1·06
August	1·01	1·09	1·12	1·09	1·05	1·09	1·10	1·13
September	1·01	1·01	1·09	1·14	1·03	1·06	1·07	1·08
October	1·00	1·02	1·01	1·04	1·02	1·01	1·02	1·03
November	·98	·87	·92	·91	1·01	1·00	·99	·99
December	·98	·81	·77	·74	·99	·96	·96	·94

Example 1.—Observed fall at Royal Observatory, Greenwich, in July 1862 to 1865 at 51 feet above the ground was 3·57; required the probable fall at the ground.

Mean annual correction for 51 feet $= \cdot623 \times 1\cdot11 = \cdot69$,

$$3\cdot57 \div \cdot69 = 5\cdot17$$

(observed fall was 5·14).

Example 2.—At Bishopwearmouth the gauge is 30 feet *above the ground*. The monthly percentage of total annual fall is in January 4·6, and in July 8·9; required the probable *true* percentage at the ground level. From the above Table ·93 may be taken as the factor for January and 1·09 for July; then $4\cdot6 \div \cdot93 = 4\cdot9$, and $8\cdot9 \div 1\cdot09 = 8\cdot2$.

Two other matters alone remain for consideration in this Report,—(1) the rainfall of the past two years for 1866–67 in continuation of previous papers published by this Association, and (2) the results of the examination of rain-gauges *in situ*.

With reference to the first subject, we have thought it expedient to draw up a Table showing the rainfall of the ten years 1850–59; also the same values reduced to the mean of fifty years by the application of the correction suggested in the British Association Report 1862, then the actual fall in each year since 1859. From thence we have determined the percentage of excess or deficiency in each year, which we believe to be far the clearest mode of exhibiting the fluctuations of rainfall.

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Above sea-level.
	1868.					ft. in.	feet.
243.	Apr. 16.	MIDDLESEX. Upper Holloway. *W. B. KESTEVEN, ESQ.* *W. B. Kesteven, Esq.*	XII.	Casella	9 a.m.	1 3	95
244.	Apr. 18.	KENT. Foxgrove, Beckenham. *P. BICKNELL, ESQ.* *P. Bicknell, Esq.*	XI.	Negretti & Zambra	9 a.m.	0 5	142
245.	May 1.	MIDDLESEX. Beaulieu, Winchmore Hill. *T. PAULIN, ESQ.* *T. Paulin, Esq.*	X.	Negretti & Zambra	9 a.m. 9 p.m.	0 11	....
246.	July 13.	SURREY. West Hill, Wandsworth. *J. E. RICHARD, ESQ.* *J. E. Richard, Esq.*	III.	Casella	5 p.m.	0 10	86
247.	Aug. 7.	HAMPSHIRE. Bramshill House, Reading. *REV. SIR W. COPE, BART.* *Rev. Sir W. Cope, Bart.*	XI.	Negretti & Zambra	9 a.m.	1 3	301
248.	Aug. 10.	HAMPSHIRE. The Vyne, Basingstoke. *W. L. WIGGETT CHUTE, ESQ.* *W. L. Wiggett Chute, Esq.*	X.	Negretti & Zambra	9 a.m.	1 3	236
249.	Aug. 10.	HAMPSHIRE. The Vyne, Basingstoke. *W. L. WIGGETT CHUTE, ESQ.* *W. L. Wiggett Chute, Esq.*	III.	Casella	9 a.m.	0 10	236
250.	Aug. 10.	HAMPSHIRE. Sherborn, St. John, Basingstoke. *THE REV. D. CHUTE.*	XI.	Negretti & Zambra	....	1 6	276
251.	Aug. 11.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	X.	Casella	9 a.m.	1 0	209
252.	Aug. 11.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	X.	Casella	9 a.m.	1 0	209

RAIN-GAUGES (*continued from last Report*).

Diameters (that marked M = mean).	Equivalents of water. Scale-point.	Grains.	Error at scale-point, specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position, &c.	Reference number.
in.	in.		in.			
4·99	·01	50	correct.	E.N.E. House 42°.	On lawn, clear except as noted; no better position available. Gauge had been tested before erection.	243.
4·99	·1	500	−·001	S.W. Trees 30°.		
5·02	·2	995	correct.			
5·01	·3	1500	−·002			
M 5·003	·5	2485	−·001			
4·98	·1	498	correct.	....	Clear good position; grounds level and not very much wooded.	244.
5·00	·2	998	−·001			
5·01	·3	1500	−·003			
5·01	·4	1990	−·001			
M 5·000	·5	2480	correct.			
7·98	·1	1258	+·001	S.W. Trees 31°.	On level lawn, but rather sheltered by trees, especially in E.	245.
8·01	·2	2550	−·001	S. Fir 35°.		
8·00	·3	3800	+·001	N.E. House 18°.		
8·00	·4	5050	+·002	E. Trees 30°.		
M 7·998	·5	6350	correct.			
3·01	·1	160	+·010	N.N.E. Tree 60°.	On a slope to S.S.E., in a garden containing and surrounded by a good many trees.	246.
3·00	·2	350	+·004	N.E. Tree 45°.		
3·00	·3	530	+·003	W.S.W. Tree 42°.		
2·99	·4	700	+·008			
M 3·000	·5	910	−·010			
5·03	·1	500	−·001	W.S.W. House 57°.	On the edge of the South Terrace, from which the fall is about 7 ft.; the gauge is therefore open to the full sweep of the southerly winds, and sheltered from all northerly ones. The house stands on an eminence, commanding all the surrounding country.	247.
4·99	·2	1000	−·001	N.W. House 55°.		
5·00	·3	1500	−·002	N.E. House 45°.		
5·00	·4	2000	−·003			
M 5·005	·5	2500	−·003			
8·02	·1	1380	−·009		These two gauges stand close together on the lawn in front of the Vyne, but so distant from it as to be quite uninfluenced by the house, or, indeed, by anything, as there are neither trees nor buildings near. Surrounding country gently undulating.	248.
7·96	·2	2550	−·001			
8·02	·3	3850	−·004			
7·98	·4	5100	−·002			
M 7·995	·5	6550	−·017			
3·00	·1	160	+·011			249.
3·01	·2	340	+·010			
3·01	·3	530	+·004			
3·00	·4	700	+·009			
M 3·005	·5	920	−·014			
5·02	·1	500	−·001	W. Tree 46°.	In gently undulating country near the banks of a stream; position fair, except as noted in previous column.	250.
5·00	·2	1000	−·001			
5·00	·3	1490	correct.			
5·01	·4	1980	+·002			
M 5·008	·5	2480	+·001			
24·04	·01	1145	correct.	....	This and the subsequent eleven gauges are in a portion of grass land containing 400 square feet, inclosed only by an iron two-rail fence. There is not even a bush within 30 feet, and no tree within 100 feet. The ground is quite level. The enclosure is marked N. on the plan given at page 434.	251.
23·95	·1	11425	correct.			
24·08	·15	17140	−·001			
23·94	·2	22850	−·001			
M 23·995						
12·00	·1	2850	correct.			252.
12·02	·2	5780	−·002			
11·95	·3	8568	correct.			
12·02	·4	11435	correct.			
M 11·997	·5	14280	correct.			

EXAMINATION OF

Reference number.	Date of examination.	COUNTY. Station. *OWNER.* *Observer.*	Construction of gauge.	Maker's name.	Time of reading.	Height of gauge. Above ground.	Above sea-level.
	1868.					ft. in.	feet.
253.	Aug. 12.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	VII.	Casella	9 a.m.	1 0	209
254.	Aug. 12.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	X.	Casella	9 a.m.	1 0	209
255.	Aug. 12.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	X. with flange.	Negretti & Zambra	9 a.m.	1 0	209
256.	Aug. 12.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	VII.	Casella	9 a.m.	1 0	209
257.	Aug. 12.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	XII.	Casella	9 a.m.	1 0	209
258.	Aug. 12.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	XII.	Casella	9 a.m.	1 0	209
259.	Aug. 13.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	XII. with deep flange.	Casella	9 a.m.	1 0	209
260.	Aug. 13.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	XII.	Casella	9 a.m.	1 0	209
261.	Aug. 13.	HAMPSHIRE. Strathfield Turgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	XII.	Casella	9 a.m.	1 0	209
262.	Aug. 13.	HAMPSHIRE. StrathfieldTurgis Rectory, Winchfield. *COL. WARD.* *The Rev. C. H. Griffith.*	XII.	Casella	9 a.m.	1 0	209
263.	Aug. 25.	HAMPSHIRE. Strathfieldsaye. *DUKE OF WELLINGTON.* *Mr. Bell.*	X.	Anonymous	6 p.m.	0 11	183

RAIN-GAUGES (*continued*).

Diameters (that marked M = mean).	Equivalents of water.		Error at scale-point, specified in previous column.	Azimuth and angular elevation of objects above mouth of rain-gauge.	Remarks on position, &c.	Reference number.
	Scale-point.	Grains.				
in.	in.		in.			
10·00	·1	2525	correct.			253.
9·98	·2	5050	correct.			
10·02	·3	7575	correct.			
10·00	·4	10100	correct.			
M 10·000	·5	12650	−·001			
8·00	·1	1270	correct.			254.
8·00	·2	2540	correct.			
8·01	·3	3810	correct.			
7·99	·4	5075	correct.			
M 8·000	·5	6350	correct.			
8·01	·1	1270	correct.	....	The same glass is used for both No. 255 and No. 254.	255.
7·99	·2	2540	correct.			
8·00	·3	3810	correct.			
8·00	·4	5075	correct.			
M 8·000	·5	6350	correct.			
5·02 sq.	·1	640	correct.			256.
5·03 ,,	·2	1275	correct.			
5·04 ,,	·3	1915	correct.			
5·02 ,,	·4	2555	correct.			
M 5·027	·5	3190	correct.			
6·00	·1	715	correct.			257.
6·02	·2	1430	correct.			
5·99	·3	2140	correct.			
5·99	·4	2860	correct.			
M 6·000	·5	3580	−·001			
5·01	·1	495	correct.			258.
5·00	·2	990	correct.			
4·99	·3	1490	−·001			
5·00	·4	1985	correct.			
M 5·000	·5	2480	correct.			
5·01	·1	495	correct.	....	The same glass is used for both No. 259 and No. 258.	259.
4·99	·2	990	correct.			
5·00	·3	1490	−·001			
5·00	·4	1985	correct.			
M 5·000	·5	2480	correct.			
4·01	·1	320	−·001			260.
4·01	·2	635	correct.			
3·99	·3	955	−·001			
3·99	·4	1270	correct.			
M 4·000	·5	1590	−·001			
2·00	·1	79	correct.			261.
2·00	·2	160	correct.			
2·00	·3	238	+·001			
2·00	·4	318	+·002			
M 2·000	·5	400	+·002			
1·00	·1	20	−·001			262.
1·00	·2	39	+·003			
1·00	·3	58	+·007			
1·00	·4	78	+·008			
M 1·000	·5	98	+·007			
8·00	·01	130	correct.	E.S.E. Wall 18°.	In the gardens at Strathfieldsaye —a good position.	263.
8·00	·1	1280	−·001			
8·00		3810	correct.			
8·00	·3	6320	+·002			
M 8·000	·5					

TABLES OF MONTHLY RAIN

ENGLAND AND WALES.

Height of Rain-gauge above Ground …… Sea-level……	Division I.—Middlesex. Middlesex. Hammer-smith. 1 ft. 0 in. 12 ft.		Camden Town. 0 ft. 4 in. 100 ft.		Upper Clapton. 2 ft. 6 in. 90 ft.		Hampstead. 1 ft. 0 in. 360 ft.		Brittany House, Mill Hill, Hendon. 1 ft. 0 in. 420 ft.		Div. II.–S.E. Counties. Surrey. Dunsfold, Godalming. 0 ft. 6 in. 166 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	3·80	2·49	3·90	2·81	4·82	2·55	4·33	3·12	3·24	2·88	3·78	2·51
February …	3·66	1·42	3·72	1·44	4·08	1·70	3·44	1·57	3·67	1·80	4·27	1·88
March ……	2·16	2·37	1·69	2·48	1·40	1·76	1·59	1·87	1·82	2·49	1·72	2·27
April ………	1·73	1·82	1·76	2·36	2·30	2·23	1·87	2·54	1·90	2·36	1·37	2·13
May ………	2·91	2·24	2·03	2·45	1·17	2·18	2·13	2·84	1·37	3·00	1·14	1·41
June ………	3·64	1·30	3·98	1·22	3·53	1·21	4·76	1·44	3·21	1·55	1·89	1·54
July ………	·86	3·63	1·19	4·30	2·26	3·93	1·83	4·20	3·24	4·58	3·09	4·34
August ……	2·82	2·42	2·76	2·63	2·84	2·25	2·64	2·80	2·52	2·59	2·28	2·39
September …	3·70	2·33	3·89	2·23	3·09	2·10	4·56	2·46	4·23	2·79	5·03	1·88
October ……	2·14	1·77	2·32	1·92	2·53	2·01	2·19	2·48	1·99	2·17	1·00	2·51
November …	1·43	·80	1·73	·86	1·80	·26	1·85	·92	2·18	·96	1·48	·56
December …	1·77	1·40	2·63	1·59	2·50	2·39	2·71	1·84	2·60	1·78	1·76	1·43
Totals ……	30·62	23·99	31·60	26·29	32·32	24·57	33·90	28·08	31·97	28·95	28·81	24·85

Height of Rain-gauge above Ground …… Sea-level……	Division II.—South-Eastern Counties (*continued*). Kent (*continued*). Tunbridge. 1 ft. 0 in. 125 ft.		River Hill, Sevenoaks. 9 ft. 0 in. 520 ft.		Acol, Margate. 1 ft. 0 in. 60 ft.		Sidcup, Foots Cray. 0 ft. 7 in. …………		West Sussex. Aldwick, Bognor. 0 ft. 6 in. 8 ft.		Brighton Water Works. 1 ft. 0 in. 90 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	5·85	3·15	4·57	3·13	2·99	2·04	3·23	1·76	4·24	2·78	4·30	3·01
February …	5·90	1·87	4·33	1·48	3·51	1·11	3·92	1·14	4·04	1·52	4·49	2·13
March ……	2·23	2·61	1·56	2·88	2·35	2·26	1·50	2·62	1·54	2·94	2·07	3·21
April ………	2·12	1·67	2·44	1·16	1·92	1·29	2·57	2·22	1·04	1·17	1·77	1·30
May ………	1·01	1·70	1·65	1·57	1·13	4·36	3·69	1·89	·70	1·69	·70	2·43
June ………	4·00	1·62	2·46	1·82	2·44	2·84	3·54	1·30	1·95	1·48	2·32	1·47
July ………	3·03	4·69	2·14	3·29	3·42	2·40	1·74	5·18	1·61	2·48	2·57	3·61
August ……	1·88	1·89	2·46	2·36	3·17	1·29	2·13	2·34	1·56	2·32	2·23	2·12
September …	6·04	1·54	7·38	1·92	3·52	1·29	4·56	1·45	4·55	1·40	6·09	2·34
October ……	1·37	2·44	1·62	3·24	·42	1·43	1·47	1·89	1·39	2·65	2·11	3·12
November …	2·19	·92	2·33	·52	2·10	1·22	1·15	·79	1·40	1·26	2·24	1·35
December …	1·59	2·61	2·02	3·08	1·49	1·67	1·54	1·65	1·81	·82	2·79	3·29
Totals ……	37·21	26·71	34·96	26·45	28·46	23·20	31·04	24·23	25·83	22·51	33·68	29·38

FALL IN THE BRITISH ISLES.

ENGLAND AND WALES.

Division II.—South-Eastern Counties (*continued*).

Surrey (*continued*).								Kent.					
Weybridge Heath.		Bagshot Park.		Kew Observatory.		S. Fields, Wandsworth.		Dover.		Horton Park, Hythe.		Linton Park, Staplehurst.	
0 ft. 6 in. 150 ft.		1 ft. 1 in. 230 ft.		1 ft. 3 in. 19 ft.		1 ft. 0 in.		2 ft 2 in. 16 ft.		1 ft. 4 in. 350 ft.		0 ft. 6 in. 200 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·75	3·41	3·27	2·39	3·43	2·21	3·63	3·30	4·88	3·75	4·30	3·04	3·83	3·05
4·41	1·45	4·09	1·59	3·39	1·25	4·10	1·53	3·95	1·66	4·71	1·50	4·55	1·53
1·63	2·42	1·84	2·69	1·23	1·98	1·57	1·96	3·00	2·95	2·73	3·22	2·27	3·42
2·09	2·10	1·75	2·40	1·72	1·69	1·90	2·35	2·00	1·51	1·29	1·67	2·09	1·67
1·50	1·17	2·93	1·45	1·32	1·22	2·48	1·60	1·12	2·57	1·14	3·49	·81	2·35
3·14	1·59	1·99	1·44	4·02	1·36	3·50	2·05	2·66	1·17	2·45	1·30	3·40	·85
1·04	4·43	1·88	3·26	1·20	3·61	1·25	4·85	2·55	3·62	2·84	4·47	2·73	4·53
2·28	3·23	2·62	2·03	2·31	2·06	2·75	2·80	4·24	·92	4·46	1·12	2·15	1·55
3·61	2·03	4·23	2·30	3·59	2·26	3·55	2·30	6·13	1·22	5·41	1·34	4·25	1·43
1·13	2·08	1·38	1·96	1·63	1·62	2·15	1·93	·84	2·67	1·14	2·73	1·38	2·65
1·48	·68	1·31	·25	1·27	·78	1·47	·60	2·88	2·23	2·94	1·99	1·89	1·26
1·90	1·37	2·06	1·77	1·70	1·29	1·95	1·44	2·70	2·64	2·33	2·51	1·47	2·42
7·96	25·96	29·35	23·53	26·81	21·33	30·30	26·71	36·95	26·91	35·74	28·38	30·82	26·71

Division II.—South-Eastern Counties (*continued*).

West Sussex (*continued*).

West Thorney.		Chichester Museum.		Bleak House, Hastings.		Dale Park, Arundel.		Battle.		Chilgrove, Chichester.		St. Leonard's Lodge, Horsham.	
1 ft. 0 in. 10 ft.		0 ft. 6 in. 20 ft.		1 ft. 3 in. 80 ft.		4 ft. 0 in. 316 ft.		1 ft. 3 in.		0 ft. 6 in. 284 ft.		1 ft. 6 in. 300 ft.	
66.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
5·82	3·34	6·15	3·32	5·00	3·68	8·28	2·61	5·33	4·42	4·78	3·65	4·94	3·54
3·34	1·74	4·78	1·77	3·71	1·86	5·44	2·77	5·02	2·20	4·49	2·66	4·00	1·51
1·15	2·24	1·83	3·08	2·39	3·08	1·20	3·54	2·23	3·81	1·79	2·05	2·02	2·40
1·34	1·18	1·10	1·55	2·20	2·51	1·71	1·93	2·21	2·35	1·58	2·06	1·45	2·28
·92	1·27	·96	1·68	1·04	3·14	1·08	2·14	1·09	3·66	1·43	1·40	1·01	1·50
·95	1·10	1·90	1·95	1·78	·71	2·95	2·28	1·77	1·55	2·94	1·85	2·76	2·38
·29	2·60	1·77	4·03	1·86	3·77	2·12	5·67	2·05	4·06	1·99	4·76	1·36	4·96
·38	1·43	2·31	3·21	2·33	·96	2·77	3·20	3·25	1·75	3·24	3·41	1·61	2·13
·09	2·19	6·18	1·92	6·20	·60	8·15	2·01	6·62	1·89	8·08	2·24	8·26	2·25
·51	4·20	1·43	3·17	1·47	2·74	1·52	3·54	1·72	3·56	1·50	2·82	1·60	4·71
·85	1·09	1·87	1·41	2·18	·85	2·70	1·90	2·90	2·00	2·10	1·03	1·70	·94
·05	1·41	1·90	·96	1·87	2·18	3·20	2·06	2·80	2·00	2·74	1·55	2·38	1·07
·69	23·79	32·18	28·05	32·03	26·08	41·12	33·65	36·99	33·25	36·66	29·48	33·09	25·67

ENGLAND AND WALES.

Division II.—South-Eastern Counties (*continued*).

	West Sussex (*continued*).		East Sussex.		Hampshire.							
Height of Rain-gauge above	Petworth Rectory.		Uckfield.		St. Lawrence, Isle of Wight.		Ryde, Isle of Wight.		Osborne, Isle of Wight.		Fareham.	
Ground ...... Sea-level......	2 ft. 0 in. 170 ft.		6 ft. 0 in. 200 ft.		1 ft. 0 in. 200 ft.		7 ft. 0 in. 15 ft.		0 ft. 6 in. 172 ft.		0 ft. 2 in. 20 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	5·55	4·11	6·22	3·15	3·78	3·49	5·96	4·45	4·48	3·72	5·41	2·8
February ...	5·54	2·39	4·35	1·70	3·17	1·81	5·63	2·29	4·88	2·26	5·22	3·6
March	2·44	3·20	1·95	3·02	2·50	3·94	2·45	3·63	2·20	2·78	3·08	3·4
April	1·81	2·61	1·25	2·24	2·37	1·34	1·59	2·22	1·52	1·82	1·46	2·4
May	1·06	2·05	·70	2·07	·81	2·30	·86	1·73	1·20	1·93	1·29	1·4
June	2·84	2·07	2·77	1·87	1·51	·97	2·08	1·45	1·64	1·62	2·68	2·9
July	1·94	5·27	2·83	5·25	·83	2·44	1·59	3·48	1·51	3·71	2·03	3·6
August	2·34	2·40	2·07	1·96	2·23	2·75	2·31	2·36	2·60	2·52	2·75	3·5
September ...	6·91	2·05	6·12	2·33	6·49	1·60	7·62	2·21	8·66	2·16	7·70	2·0
October	·94	3·59	1·61	3·41	1·35	3·77	1·66	3·42	1·60	3·56	2·41	1·8
November ...	1·75	1·27	1·89	1·41	1·54	1·85	1·97	1·56	1·90	·80	2·77	1·5
December ...	2·45	1·10	2·03	2·07	2·02	·98	2·60	·76	1·98	·80	2·65	1·6
Totals	35·57	32·11	33·79	30·48	28·60	27·24	36·32	29·56	34·17	27·68	39·45	30·9

Division III.—South Midland Counties (*continued*).

	Hertfordshire (*continued*).		Oxford.				Northampton.				Bedford.	
Height of Rain-gauge above	Hitchin.		Radcliffe Observatory, Oxford.		Banbury.		Althorpe House.		Welling-borough.		Cardingto[n]	
Ground ...... Sea-level......	2 ft. 0 in. 240 ft.		0 ft. 8 in. 210 ft.		7 ft. 0 in. 345 ft.		3 ft. 4 in. 310 ft.		0 ft. 8 in.		0 ft. 0 in. 100 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	186
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	3·63	3·01	2·87	2·58	2·57	3·03	2·34	2·49	2·40	2·23	2·50	2·
February ...	3·28	1·45	2·88	1·53	2·30	1·31	2·59	1·25	2·94	1·55	2·55	1·
March	1·28	2·46	1·66	2·88	1·33	3·17	1·14	2·09	1·17	2·74	1·20	2·
April	1·65	2·06	2·04	2·60	1·52	2·31	1·08	2·56	1·06	1·87	1·60	2·
May	1·04	3·03	1·66	2·50	2·17	3·02	1·61	2·91	1·51	3·01	1·34	2·
June	2·61	·85	3·20	1·93	2·46	1·80	1·66	1·85	2·06	1·24	2·25	1·
July	2·61	4·24	2·03	3·92	2·08	2·17	3·01	2·50	2·60	2·89	2·75	3·
August	3·16	1·86	2·95	2·39	3·52	2·75	5·00	2·68	3·74	2·41	3·37	2·
September ...	2·63	1·86	5·66	1·62	5·63	1·79	4·49	1·36	3·72	1·87	3·50	1·
October	1·54	1·78	2·10	2·81	2·06	2·94	1·93	2·21	1·74	2·15	1·90	1·
November ...	1·68	·61	1·54	·95	1·71	·57	1·94	·48	1·83	·17	1·62	·
December ...	1·89	1·56	2·03	1·43	1·88	1·56	1·80	2·00	1·67	2·00	2·30	1·
Totals	27·00	24·77	30·62	27·14	29·23	26·42	28·59	24·38	26·44	24·13	26·88	23·

ENGLAND AND WALES.

Division II.—South-Eastern Counties (continued).										Division III.—South Midland Counties.			
Hampshire (continued).								Berkshire.		Hertfordshire.			
Shirley Warren, 'outhampton.		Selborne.		Liss, Petersfield.		Aldershot.		Long Wittenham.		Berkhempstead.		Royston.	
4 ft. 0 in. 106 ft.		4 ft. 0 in. 565 ft.		0 ft. 8 in.		6 ft. 0 in. 331 ft.		1 ft. 0 in. 170 ft.		1 ft. 6 in. 370 ft.		0 ft. 6 in. 266 ft.	
866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
5·56	4·80	6·23	4·11	6·63	2·81	4·98	2·92	3·83	3·42	4·32	3·73	2·89	2·78
4·32	2·18	5·47	2·54	6·37	2·07	3·87	1·78	3·32	1·57	3·71	1·82	2·78	1·12
2·46	2·69	2·72	3·10	2·30	3·12	1·72	2·98	1·76	2·47	1·99	2·71	1·34	2·00
2·24	2·23	1·28	3·21	2·70	1·36	2·11	2·13	1·76	2·41	1·80	2·85	1·64	2·13
1·74	·74	1·56	1·66	1·47	1·45	1·30	1·11	·77	2·20	1·76	2·88	1·62	3·60
1·82	1·32	2·84	1·98	2·53	1·98	2·91	1·34	3·77	1·58	4·32	1·31	2·17	·81
1·25	4·78	1·38	4·82	2·98	5·25	2·22	3·94	2·69	4·97	1·85	4·66	2·47	3·39
3·02	1·79	2·66	2·43	3·05	3·02	2·52	1·95	2·77	2·63	3·46	2·02	2·77	1·79
7·22	3·19	6·52	2·65	7·42	3·19	4·81	1·96	5·69	1·62	5·12	1·89	3·20	2·73
1·45	3·01	1·66	3·68	1·74	4·20	1·46	2·38	1·94	2·94	1·31	2·17	1·44	2·38
2·04	·80	2·08	1·06	2·39	1·34	1·66	·35	1·54	·31	2·35	·75	1·82	·47
2·00	1·43	3·08	1·49	4·25	1·28	2·08	1·73	1·85	2·34	2·81	1·94	2·34	1·66
5·12	28·96	37·48	32·73	43·83	31·07	31·64	24·57	31·69	28·46	34·80	28·73	26·48	24·86

Division III.—South Midland Counties (continued).				Division IV.—Eastern Counties.									
Cambridge.				Essex.									
Wisbech.		Mid-level Sluice, Outwell.		Epping.		Dorward's Hall, Witham.		Dunmow.		Bocking, Braintree.		Ashdon Rectory, Linton.	
8 ft. 0 in. 18 ft.		4 ft. 0 in. 16 ft.		6 ft. 0 in. 300 ft.		1 ft. 6 in. ? 20 ft.		0 ft. 3 in. 234 ft.		3 ft. 0 in. 300 ft.		1 ft. 0 in. 300 ft.	
866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
n.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1·91	2·66	1·87	2·11	3·90	2·40	2·75	2·30	2·20	2·77	2·80	2·62	2·73	2·40
2·39	1·00	2·56	1·06	3·75	1·45	2·61	·88	3·43	1·32	3·68	1·64	2·72	1·23
·99	1·41	·64	·85	1·78	2·50	1·39	2·17	1·42	2·07	1·45	2·23	1·43	1·91
1·74	2·24	1·31	1·83	2·05	2·25	1·77	1·44	1·85	1·71	2·31	2·35	1·88	2·06
1·67	3·57	2·01	2·71	1·30	3·60	1·02	2·61	1·62	2·79	1·20	3·55	·74	3·30
2·42	1·27	2·61	1·11	3·75	1·45	2·80	·94	2·93	1·28	1·98	·80	3·53	·14
2·96	3·42	2·78	3·66	1·25	4·35	1·62	2·52	2·05	2·91	2·94	2·93	2·12	2·21
3·32	2·09	3·67	1·80	2·55	2·50	2·44	1·56	3·23	2·34	3·06	1·85	3·24	2·65
2·58	2·20	2·36	2·31	4·25	2·25	3·04	1·16	3·55	1·85	3·56	1·94	3·05	2·46
1·32	2·28	1·29	1·96	2·10	1·95	·60	1·50	1·03	2·43	·40	2·28	·94	2·98
2·10	·69	1·93	·49	1·25	·75	1·70	·15	2·37	·62	2·48	·59	1·91	·61
1·93	2·22	1·58	1·57	1·95	1·65	1·94	2·07	2·29	1·85	2·47	2·27	2·43	2·27
5·33	25·05	24·61	21·46	29·88	27·10	23·68	19·30	27·97	23·94	28·33	25·05	26·72	24·22

ENGLAND AND WALES.

Division IV.—Eastern Counties (*continued*).

	Suffolk.				Norfolk.							
Height of Rain-gauge above	Grundisburgh.		Culford.		Geldeston, Beccles.		Cossey.		Egmere, Fakenham.		Holkham.	
Ground ...... Sea-level......	4 ft. 1 in.		1 ft. 6 in.		1 ft. 4 in. 34 ft.		1 ft. 0 in.		4 ft. 0 in. 150 ft.		0 ft. 0 in. 39 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	186
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	2·61	2·56	2·48	2·73	2·07	2·75	2·65	3·90	2·10	4·00	2·40	4·6
February ...	4·13	1·50	3·59	1·82	3·96	1·16	4·15	1·23	4·02	·71	2·98	1·1
March	1·48	1·99	1·30	1·47	1·71	1·38	1·13	1·52	1·51	1·41	1·25	1·2
April	1·79	2·05	1·85	3·17	1·38	2·08	1·54	2·27	1·89	2·58	1·00	2·1
May	2·40	3·73	1·66	2·65	1·52	3·21	1·84	2·87	1·46	4·19	1·47	2·
June	2·30	·69	3·42	·73	2·73	·45	2·90	·94	2·62	·83	2·05	·5
July	2·45	2·91	2·25	4·49	2·96	3·26	2·03	3·03	1·38	4·99	2·18	4·2
August	2·35	1·08	3·39	1·49	1·36	1·03	1·22	1·83	3·59	1·36	2·97	1·1
September ...	3·90	1·30	3·01	2·63	3·09	1·72	2·44	2·68	3·62	2·27	2·90	2·0
October	·45	2·57	·54	2·48	·57	2·57	1·01	2·50	·99	2·32	·90	2·0
November ...	2·44	·79	2·66	·95	3·06	·83	3·34	1·05	3·75	1·17	3·30	·8
December ...	2·70	2·01	2·58	2·66	2·45	1·98	2·62	2·99	2·78	3·87	2·00	2·7
Totals	29·00	23·18	28·73	27·27	26·86	22·42	26·87	26·81	29·71	29·70	25·40	25·6

Division V.—South-Western Counties (*continued*).

Devon (*continued*).

Height of Rain-gauge above	Torhill, Ivy Bridge.		High Wick, Newton Bushel.		Landscore, Teignmouth.		Dawlish.		Broad-hembury, Honiton.		Cove, Tiverton.	
Ground ...... Sea-level......	0 ft. 4 in. 240 ft.		1 ft. 6 in. 250 ft.		0 ft. 6 in. 200 ft.		0 ft. 8 in. 62 ft.		1 ft. 6 in. 400 ft.		0 ft. 10 in. 450 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	8·48	7·53	6·77	5·98	5·07	7·13	7·11	5·54	4·92	4·62	7·63	5·2
February ...	6·18	5·32	5·94	3·29	3·71	3·14	3·43	2·84	4·00	2·94	4·79	4·0
March	4·23	7·74	4·57	7·71	4·55	10·22	4·02	6·69	3·41	4·96	4·42	5·6
April	2·90	3·35	2·46	3·33	2·96	2·16	2·33	2·52	2·44	2·70	2·22	4·1
May	3·58	5·68	2·60	5·51	2·91	5·40	3·05	6·18	1·77	2·92	2·77	3·1
June	2·58	1·50	1·24	·49	·76	·33	·99	·63	1·21	1·72	2·23	1·1
July	1·81	5·61	·55	4·86	1·26	2·39	·79	4·56	1·97	4·75	2·17	3·9
August	6·37	1·38	1·85	·94	1·37	1·22	1·95	1·52	2·07	1·50	3·31	1·2
September ...	11·90	4·37	8·31	2·08	13·18	1·49	7·88	2·74	8·19	2·34	9·90	2·2
October	2·71	6·05	2·68	2·79	4·81	2·88	3·48	2·89	3·05	4·01	2·31	4·3
November ...	3·28	2·30	1·46	·85	1·24	·46	1·67	·40	2·05	1·47	3·02	1·1
December ..	6·66	3·15	2·97	1·61	2·24	3·52	2·48	2·97	3·28	1·76	4·79	2·4
Totals	60·68	53·98	41·40	39·44	44·06	40·34	39·18	39·48	38·36	35·69	49·56	38·6

ENGLAND AND WALES.

Division V.—South-Western Counties.

Wiltshire.						Dorset.						Devon.	
Baverstock.		Marlborough.		Calne.		Encombe, Wareham.		Dorchester.		Bridport.		Saltram Gardens, Plymouth.	
3 ft. 0 in. 300 ft.		4 ft. 0 in. 500 ft.		0 ft. 11 in. 250 ft.		0 ft. 6 in. 150 ft.		0 ft. 6 in. 250 ft.		0 ft. 11 in. 85 ft.		0 ft. 3 in. 96 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
·05	4·15	4·16	3·34	3·60	3·34	4·06	3·96	6·05	5·70	5·16	4·54	8·07	6·40
·10	2·85	3·80	2·44	3·98	1·95	4·30	1·68	4·77	3·23	3·73	2·60	5·09	2·75
·75	4·60	2·26	3·26	2·07	3·35	1·84	4·38	2·02	4·02	2·26	3·73	3·60	6·49
·40	1·90	2·21	2·60	2·17	3·25	1·34	2·20	2·38	2·21	1·86	2·58	2·41	3·60
·35	1·90	1·84	2·26	1·15	1·80	1·30	2·08	1·71	2·92	2·19	1·86	3·35	4·25
·90	1·20	3·01	1·55	3·02	2·18	1·40	1·35	2·39	1·22	1·58	1·06	2·14	1·91
·40	3·50	1·46	3·86	1·49	3·79	1·35	3·20	·81	4·51	1·25	3·78	1·50	5·49
·40	2·00	2·85	2·26	2·52	3·07	2·05	2·05	3·34	2·17	2·48	2·24	5·25	1·30
·80	2·45	7·31	2·14	6·65	1·92	8·90	1·72	9·34	2·93	7·39	1·81	10·87	3·80
·51	3·46	1·70	3·10	2·07	2·83	2·60	3·46	2·09	2·94	2·20	2·80	2·55	5·40
·25	·70	2·25	1·35	2·31	1·15	2·15	·94	2·50	1·72	1·99	1·54	3·03	2·86
·65	1·16	3·00	1·50	2·87	1·65	3·10	1·05	2·97	1·59	2·68	1·91	5·09	2·55
·56	29·87	35·85	29·66	33·90	30·28	34·39	28·05	40·37	35·16	34·77	30·45	52·95	46·80

Division V.—South-Western Counties (*continued*).

Devon (*continued*).						Cornwall.							
[illegible]tle Hill, [illegible]Molton.		Great Torrington.		Barnstaple.		Helston.		Penzance.		Tehidy Park, Redruth.		Truro.	
[illegible]t. 0 in. [illegible]50 ft.		1 ft. 1 in. 321 ft.		0 ft. 6 in. 31 ft.		5 ft. 0 in. 115 ft.		2 ft. 6 in. 94 ft.		0 ft. 0 in. 100 ft.		40 ft. 0 in. 56 ft.	
[illegible]	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
[illegible]	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
[illegible]	5·12	5·58	7·63	5·44	5·89	6·30	5·12	7·05	5·57	6·10	7·80	6·92	6·74
[illegible]	4·91	4·94	4·03	4·56	3·57	4·02	3·70	5·65	3·52	4·00	3·32	5·41	3·37
[illegible]	3·91	3·13	3·19	3·23	3·22	4·15	5·70	3·76	5·14	4·40	6·20	4·63	5·44
[illegible]	4·23	1·37	4·15	1·46	3·49	3·91	3·24	4·22	3·12	4·00	3·80	3·94	3·46
[illegible]	2·72	1·30	3·39	1·05	2·63	1·64	3·68	2·10	2·84	2·74	3·50	2·45	3·53
[illegible]	1·09	2·06	1·18	2·48	1·02	2·20	1·08	2·45	·35	3·45	1·00	3·27	1·13
[illegible]	6·10	1·83	4·53	2·60	3·73	·97	3·78	·96	4·00	1·53	3·50	·85	3·81
[illegible]	2·33	4·24	1·92	3·99	2·24	4·67	1·35	4·80	1·19	4·90	·85	4·69	·99
[illegible]	2·46	8·72	2·22	7·07	2·19	7·67	·92	7·15	1·28	7·70	1·95	7·88	1·33
[illegible]	7·80	2·05	7·53	2·13	7·12	2·01	4·92	2·00	5·16	3·80	5·53	2·63	5·70
[illegible]	·93	3·46	1·37	4·01	1·08	1·40	1·41	3·36	1·37	3·20	1·50	3·06	1·39
[illegible]	4·65	5·00	2·64	5·00	3·16	4·01	3·44	5·00	3·52	4·50	2·90	5·04	2·90
[illegible]	46·25	43·68	43·78	43·02	39·34	42·95	38·34	48·50	37·06	50·32	41·85	50·77	39·79

ENGLAND AND WALES.

Division V.—South-Western Counties (*continued*).

Height of Rain-gauge above Ground …… Sea-level……	Cornwall (*continued*). Bodmin. 2 ft. 6 in. 325 ft.		Treharrock House, Wadebridge. 3 ft. 6 in. 300 ft.		Roscarrock. 3 ft. 0 in. 210 ft.		Somerset. Fulland's School, Taunton. 1 ft. 4 in. …………		Long Sutton, near Langport. 0 ft. 7 in. …………		Sherborne Reservoir East Harptr[ee] 5 ft. 0 in. 360 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	18[67.]
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	9·27	8·01	5·36	5·47	6·34	5·34	4·82	4·85	4·85	4·15	7·30	5
February …	4·75	3·90	4·46	3·16	4·43	3·24	4·00	1·89	3·62	2·00	6·43	4
March ……	4·40	4·96	3·91	2·88	3·56	3·83	3·39	3·81	2·54	3·76	2·65	5
April ………	2·21	4·53	1·41	3·33	1·28	3·28	1·91	1·83	2·03	1·51	1·75	4
May ………	2·44	3·98	2·00	2·56	1·61	2·74	1·64	2·87	1·96	1·63	1·52	2
June ………	2·49	1·63	2·90	1·38	2·78	1·38	·77	1·39	2·28	1·02	3·24	2
July ………	2·00	5·11	1·76	5·12	1·45	4·70	1·79	3·35	1·18	3·53	3·98	5
August ……	6·49	1·61	6·88	1·59	6·07	1·36	1·68	1·47	2·39	1·74	3·97	2
September …	9·05	1·62	7·45	1·91	7·63	1·71	6·87	1·66	6·57	1·71	9·68	1
October ……	3·10	7·42	2·28	7·07	2·00	6·44	1·89	3·38	2·01	2·89	2·16	5
November …	3·75	1·48	3·29	·98	3·36	·93	1·14	·81	1·52	1·31	3·96	1
December …	5·22	3·66	4·75	2·67	4·75	2·67	2·06	1·49	2·05	1·35	5·45	3
Totals ……	55·17	47·91	46·45	38·12	45·26	37·62	31·96	28·80	33·00	26·60	52·09	44

Division VI.—West Midland Counties (*continued*). | Div. VII.—Midland Counties.

Height of Rain gauge above Ground …… Sea-level……	Worcester (*continued*). West Malvern. 1 ft. 3 in. 900 ft.		Lark Hill, Worcester. 1 ft. 0 in. 157 ft.		Orleton, Tenbury. 0 ft. 9 in. 200 ft.		Warwick. Rugby. 2 ft. 4 in. 384 ft.		Birmingham. 0 ft. 10 in. 340 ft.		Leicester. Wigston 0 ft. 6 in. 220 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	18[67.]
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ……	2·08	3·14	2·08	3·69	3·00	3·83	2·15	3·09	2·21	3·77	2·08	
February …	2·86	2·23	2·50	1·74	3·02	2·13	2·58	1·42	2·57	1·60	2·78	
March ……	1·89	4·13	1·41	3·65	2·30	3·84	1·22	2·57	2·07	5·66	1·27	
April ………	1·35	1·89	1·46	1·74	1·69	3·10	1·23	2·37	1·07	2·43	1·31	
May ………	·90	3·02	2·57	2·00	·94	2·24	1·39	2·39	1·16	·95	1·10	
June ………	3·63	·96	3·11	1·41	5·79	1·20	2·33	3·25	3·93	1·80	2·41	
July ………	1·34	3·21	1·59	3·59	2·16	2·96	3·14	2·46	2·10	2·49	2·21	
August ……	3·82	2·40	3·70	1·91	2·98	2·19	4·08	3·43	4·07	2·49	4·41	
September …	5·33	2·68	5·40	2·86	6·68	1·79	6·20	3·49	6·20	3·59	5·43	
October ……	2·99	2·01	2·64	2·33	2·66	3·20	1·97	2·69	2·57	2·85	2·40	
November …	1·47	1·85	1·25	1·28	1·66	1·19	1·74	·49	2·35	1·01	2·28	
December …	1·72	1·07	1·74	1·23	1·74	1·60	1·87	1·86	1·90	2·40	2·15	
Totals ……	29·38	28·59	29·45	27·43	34·62	29·27	29·90	29·51	32·20	31·04	29·83	[illegible]

ENGLAND AND WALES.

.—S.- UNTIES (…nued).	Division VI.—West Midland Counties.											
ERSET (…nued).	Gloucester.						Shropshire.				Worcester.	
…easton …rvoir.	Clifton.		Cirencester.		Park House, Gloucester.		Haughton Hall, Shifnall.		Hengoed, Oswestry.		Northwick Park.	
0 in. …5 ft.	0 ft. 6 in. 192 ft.		1 ft. 2 in. 446 ft.		3 ft. 6 in. 50 ft.		4 ft. 6 in. 450 ft.		6 ft. 0 in. 471 ft.		1 ft. 6 in.	
1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·68	4·22	4·87	4·13	5·00	2·75	3·37	1·94	3·21	4·75	5·04	2·84	2·24
1·99	4·80	2·71	4·04	2·00	2·11	1·68	2·03	1·63	4·32	2·90	2·95	2·47
2·56	2·09	4·86	1·40	3·49	2·07	2·58	1·76	2·91	2·42	3·15	2·11	3·52
3·13	1·68	3·41	2·15	3·33	·75	1·56	·74	2·21	1·02	3·82	2·11	2·23
1·82	1·12	2·52	·73	2·98	·91	2·12	1·47	1·93	2·16	3·56	·99	1·81
1·87	3·62	2·07	4·15	1·88	2·54	·76	3·31	1·21	4·08	1·46	3·47	2·09
3·81	2·66	2·73	2·10	4·29	1·48	1·46	1·27	2·89	1·46	2·59	2·55	2·28
2·05	3·26	2·05	4·54	2·57	3·12	1·60	4·50	2·20	4·30	1·22	2·29	1·97
2·03	7·40	1·34	7·10	1·60	6·26	1·81	5·40	1·22	8·01	2·00	8·77	1·94
3·62	1·92	3·64	2·15	3·50	2·13	2·46	2·37	3·05	1·98	4·69	2·13	1·97
1·08	2·39	2·20	2·03	1·05	1·32	1·25	3·49	1·08	3·31	1·46	2·25	1·60
1·52	4·95	1·5	3·45	2·01	1·68	1·11	1·65	1·89	2·72	1·89	2·13	1·86
29·16	40·11	33·97	37·97	33·70	27·12	21·76	29·93	25·43	40·53	33·78	34·59	25·98

Division VII.—North Midland Counties (*continued*).												
…cester (*continued*).			Lincoln.									
…nton.	Belvoir Castle.		Lincoln.		Market Rasen.		Gainsborough.		Brigg.		Grimsby.	
8 in. …20 ft.	1 ft. 0 in. 237 ft.		3 ft. 6 in. 26 ft.		3 ft. 6 in. 100 ft.		3 ft. 6 in. 76 ft.		3 ft. 6 in. 16 ft.		15 ft. 0 in. 42 ft.	
1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·06	1·50	3·12	·83	1·96	1·36	3·47	1·05	1·72	1·48	2·05	1·88	1·87
1·42	2·09	1·73	1·60	1·44	2·00	1·73	1·77	·46	1·89	1·34	2·20	1·10
2·16	1·64	2·90	1·00	1·37	1·76	2·08	·59	1·69	1·50	2·64	1·48	1·63
2·70	1·40	2·41	·94	3·26	2·05	2·07	1·65	2·00	·90	2·79	1·16	2·42
1·92	1·24	2·90	1·21	3·02	1·15	2·58	1·18	1·67	1·24	1·59	1·31	2·07
1·76	3·12	1·85	2·74	1·64	3·51	1·76	2·89	1·66	3·48	1·31	3·49	1·33
1·88	3·21	2·70	2·14	1·99	2·64	2·87	2·34	2·17	3·94	2·37	2·56	2·67
2·41	4·73	2·65	3·58	2·12	3·61	2·63	2·18	2·87	2·49	1·85	2·49	1·49
3·41	4·54	1·93	3·54	1·61	6·39	1·36	3·25	1·46	3·69	1·94	3·79	2·07
2·39	2·44	2·20	2·06	2·04	3·09	2·61	2·40	1·55	2·36	1·96	1·68	1·90
·61	2·00	·47	1·85	1·15	3·19	1·46	1·97	·83	2·94	·78	2·64	1·06
2·49	1·48	2·20	1·13	1·86	2·01	·82	·97	1·58	1·98	2·23	1·54	1·97
26·21	29·39	27·06	22·62	23·46	32·76	25·44	22·24	19·66	27·89	22·85	26·22	21·58

ENGLAND AND WALES.

Division VII.—North Midland Counties (*continued*).

	Lincoln (*continued*).		Nottingham.		Derby.							
Height of Rain-gauge above	New Holland.		Welbeck.		Derby.		Chesterfield.		Comb's Moss.		Chapel-en-le-Frith.	
Ground ...... Sea-level......	3 ft. 6 in. 18 ft.		3 ft. 10 in. 80 ft.		5 ft. 0 in. 180 ft.		3 ft. 6 in. 248 ft.		3 ft. 6 in. 1669 ft.		3 ft. 6 in. 963 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	1·30	2·35	1·03	1·88	1·60	2·91	2·49	2·77	6·03	3·68	5·42	3·73
February ...	1·90	·89	2·39	1·25	2·25	1·95	3·30	2·53	4·98	3·97	4·74	4·63
March	1·31	1·69	1·31	2·40	1·72	2·09	1·22	2·07	2·66	2·55	2·85	2·34
April	·66	2·23	1·32	3·04	1·05	3·42	1·29	2·98	1·86	8·65	1·39	6·44
May	1·17	1·56	·65	2·35	1·75	1·73	·72	2·63	2·10	1·91	1·87	1·93
June	3·39	1·17	3·40	2·25	4·11	2·38	3·79	2·10	6·27	2·54	5·19	2·25
July	2·22	2·53	3·04	3·39	2·41	1·92	2·94	3·19	6·43	5·52	4·07	4·83
August	2·50	1·44	3·24	3·31	6·56	4·21	3·38	3·79	6·02	3·08	5·47	2·51
September ...	3·90	1·71	3·83	2·10	4·79	2·86	4·51	2·72	7·92	3·96	6·36	2·92
October	2·02	1·50	2·84	2·02	2·95	3·30	2·93	2·56	5·02	5·39	3·04	4·75
November ...	2·96	1·29	2·07	·89	3·06	·95	2·78	·80	9·22	2·82	7·10	1·34
December ...	1·51	2·18	1·56	1·51	2·22	1·65	2·02	1·89	5·05	4·88	4·79	5·84
Totals	24·84	20·54	26·68	26·39	34·47	29·37	31·37	30·08	63·56	48·95	52·29	43·51

Division VIII.—North-Western Counties (*continued*). / Div. IX.—Yorkshire.

	Lancashire (*continued*).								York.—West Riding.			
Height of Rain-gauge above	South Shore, Blackpool.		Stonyhurst.		Caton, Lancaster.		Holker, Cartmel.		Broomhall Park, Sheffield.		Redmires, Sheffield.	
Ground ...... Sea-level......	1 ft. 8 in. 29 ft.		1 ft. 3 in. 381 ft.		1 ft. 9 in. 120 ft.		4 ft. 8 in. 155 ft.		2 ft. 0 in. 337 ft.		4 ft. 0 in. 1100 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	4·10	3·00	6·30	4·45	5·90	4·40	5·69	5·21	2·78	3·00	3·96	3·18
February ...	3·25	1·95	5·24	4·35	4·21	3·37	4·26	2·85	3·36	2·69	4·67	4·80
March	2·05	1·08	2·52	1·45	2·84	1·86	2·96	1·71	2·03	2·50	2·66	2·61
April	·80	2·90	1·10	5·93	·85	4·15	1·38	4·23	1·41	4·00	2·12	5·30
May	1·15	2·05	2·07	2·10	1·52	2·56	1·38	2·05	·92	2·65	1·35	1·96
June	3·12	·80	4·87	2·14	4·25	1·48	2·75	1·60	4·18	2·52	5·80	2·42
July	3·15	4·15	6·20	5·43	4·51	3·87	2·73	4·89	4·00	3·76	4·64	4·91
August	3·55	1·85	6·15	3·51	5·19	3·28	5·78	3·29	3·10	2·73	4·00	2·83
September ...	6·97	2·60	9·72	4·94	8·35	3·73	8·74	4·36	4·87	2·46	5·53	3·13
October	2·30	5·57	2·94	5·36	2·63	4·72	2·64	4·94	2·98	2·84	3·29	3·33
November ...	5·52	1·04	9·44	2·16	6·68	1·39	7·07	1·88	3·52	1·09	4·93	1·32
December ...	3·95	4·05	8·40	5·22	5·78	3·53	6·12	4·06	3·01	2·12	4·78	3·06
Totals	39·91	31·04	64·95	47·04	52·71	38·34	51·50	41·07	36·16	32·36	47·73	38·85

ENGLAND AND WALES.

Division VIII.—North-Western Counties.

Cheshire.				Lancashire.									
Macclesfield.		Quarry Bank.		Manchester.		Waterhouses.		Bolton-le-Moors.		Rufford, Ormskirk.		Howick, Preston.	
3 ft. 6 in. 539 ft.		0 ft. 8 in. 295 ft.		2 ft. 7 in. 106 ft.		3 ft. 6 in. 345 ft.		3 ft. 6 in. 286 ft.		0 ft. 8 in. 38 ft.		0 ft. 6 in. 72 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2·55	3·12	2·96	3·13	3·25	3·27	3·95	3·61	5·63	4·95	3·98	3·32	4·50	3·40
3·16	2·41	2·84	2·84	2·98	2·93	3·43	3·28	5·23	3·70	3·43	2·02	3·30	2·15
2·59	1·21	2·24	1·65	2·17	1·45	1·54	1·54	2·83	1·74	2·40	1·08	2·50	1·00
1·04	3·52	·35	3·87	·30	4·32	·48	5·32	·72	5·65	·63	3·50	·80	3·80
1·73	1·51	1·41	2·10	1·54	1·95	1·74	2·36	2·07	1·82	1·35	1·27	1·40	1·55
4·13	1·66	5·03	1·74	3·98	1·59	4·73	1·76	5·24	1·30	4·15	·94	3·65	1·15
3·56	4·88	3·35	5·66	4·31	4·28	3·44	5·41	4·08	6·64	4·18	4·15	4·55	3·25
5·35	1·71	4·48	1·34	5·12	1·41	4·47	1·86	6·88	1·67	4·22	1·76	5·00	2·20
5·81	2·95	5·99	2·87	7·13	2·99	7·30	2·41	8·66	4·93	6·88	2·18	6·90	2·70
2·20	3·63	2·13	4·41	2·52	3·98	2·33	4·20	3·52	5·77	2·48	5·16	2·45	5·90
5·17	1·29	4·71	1·72	5·72	2·43	5·72	2·16	7·74	2·47	4·88	2·00	5·80	2·05
3·41	3·77	3·04	3·57	4·15	3·98	4·52	3·73	6·60	4·63	4·00	3·03	4·80	3·50
40·70	31·66	38·53	34·90	43·17	34·58	43·65	37·64	59·20	45·27	42·58	30·41	45·65	32·65

Division IX.—Yorkshire (*continued*).

York.—West Riding (*continued*).

Tickhill.		Penistone.		Saddleworth.		Longwood, Huddersfield.		Wakefield.		Well Head, Halifax.		Ovenden Moor.	
2 ft. 0 in. 61 ft.		3 ft. 6 in. 717 ft.		5 ft. 0 in. 640 ft.		4 ft. 6 in. 600 ft.		4 ft. 0 in. 115 ft.		0 ft. 11 in. 487 ft.		0 ft. 10 in. 1375 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1·88	2·51	4·31	2·01	4·14	3·62	4·20	2·67	2·02	2·10	4·75	3·29	6·10	6·00
2·18	1·23	3·85	2·34	5·18	3·43	4·66	3·50	2·66	1·65	5·22	3·31	6·90	5·00
1·63	2·01	1·48	2·65	1·50	2·63	·89	1·65	·77	2·21	1·24	2·02	1·50	2·40
1·16	2·75	1·70	3·63	2·48	5·15	1·20	4·55	1·03	3·89	1·70	4·12	1·00	6·80
1·04	2·16	1·75	2·00	1·79	4·45	1·46	2·26	·78	2·40	·96	2·72	1·20	3·10
3·38	2·08	5·52	2·53	5·69	1·82	5·02	1·74	2·88	1·88	·49	1·57	5·80	2·50
4·35	2·99	4·72	3·95	4·05	6·57	4·63	3·89	4·63	3·07	4·46	3·69	4·40	4·70
3·22	3·40	4·12	2·10	6·03	2·88	3·93	2·19	3·79	3·30	4·54	1·76	5·70	2·00
3·89	1·55	4·97	1·17	7·02	2·69	5·48	2·57	5·04	1·96	6·15	2·58	8·30	3·50
3·05	2·22	2·43	2·66	2·79	4·56	2·22	2·95	2·38	1·38	2·43	2·54	2·90	3·80
2·83	·93	4·14	1·36	6·99	2·44	5·50	1·34	4·22	1·22	5·64	·62	7·20	·60
1·81	1·63	2·86	2·06	6·00	1·36	5·62	2·39	2·54	2·14	5·66	2·72	6·20	3·40
30·42	25·46	41·85	28·46	53·66	41·60	44·81	31·70	32·74	27·20	43·24	30·94	57·20	43·80

ENGLAND AND WALES.

Division IX.—Yorkshire (*continued*).

York.—West Riding (*continued*).

Height of Rain-gauge above Ground ...... Sea-level......	W. W. Office, Manor Road, Holbeck. 0 ft. 0 in. 95 ft.		Eccup, Leeds. 0 ft. 0 in. 340 ft.		York. 0 ft. 6 in. 50 ft.		Harrogate. 0 ft. 6 in. 420 ft.		Settle. 40 ft. 0 in. 498 ft.		Arncliffe, Skipton. 3 ft. 0 in. 750 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	2·51	2·26	3·90	2·23	1·64	2·23	3·86	2·92	7·92	4·67	10·11	7·35
February ...	3·20	1·93	2·84	1·96	2·50	1·17	4·41	2·40	5·51	4·08	9·15	7·56
March	1·46	2·09	1·40	1·88	1·35	1·44	1·76	2·54	2·03	1·74	3·60	3·46
April	1·35	3·32	1·20	2·59	1·11	3·11	1·57	3·84	1·02	4·98	2·01	7·79
May	·59	1·90	·70	2·47	·58	1·78	1·25	2·24	·66	3·24	1·92	2·42
June	3·30	1·52	3·07	1·66	2·51	2·65	4·39	1·79	3·85	1·49	3·46	2·18
July	4·95	3·17	4·61	3·47	2·91	2·40	3·94	3·28	5·60	3·05	5·24	5·08
August	3·55	2·63	3·62	2·62	3·06	4·34	3·25	3·30	4·31	·94	5·33	3·65
September ...	4·51	2·05	5·37	1·84	4·04	1·75	6·11	1·85	8·25	2·98	11·19	5·27
October	2·25	1·84	2·39	1·75	1·87	1·41	2·52	2·31	2·79	3·25	4·46	4·99
November ...	4·10	1·27	4·25	·88	2·39	1·16	3·50	1·29	7·51	1·43	9·45	1·99
December ..	2·80	2·04	2·20	2·35	1·75	1·72	2·88	2·47	6·72	3·41	10·05	2·94
Totals	34·57	26·02	35·55	25·70	25·71	25·16	39·44	30·23	56·17	35·26	75·97	54·68

Division X.—Northern Counties (*continued*).

Durham (*continued*).			Northumberland.									
Height of Rain-gauge above Ground ...... Sea-level......	Sunderland. 1 ft. 6 in. 85 ft.		Allenheads. 0 ft. 5 in. 1360 ft.		Bywell. 0 ft. 6 in. 87 ft.		North Shields. 1 ft. 0 in. 124 ft.		Deadwater. 0 ft. 0 in.		Parkend, Hexham. 0 ft. 4 in. 277 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	1·13	4·78	6·81	6·10	2·57	4·07	1·51	3·61	8·40	7·00	5·50	5·40
February ...	1·43	·60	6·29	4·00	2·49	1·31	1·78	·82	6·00	3·00	3·59	2·47
March	2·83	2·31	3·25	9·10	2·58	3·26	2·47	1·69	3·50	3·10	2·25	1·51
April	2·21	1·09	4·32	6·73	3·09	2·93	1·47	1·88	3·10	4·40	2·67	3·34
May	1·01	2·57	1·63	2·46	·86	2·16	1·14	2·32	2·00	3·00	1·39	2·13
June	2·04	1·66	2·81	1·29	1·65	1·44	1·67	1·49	2·00	2·50	2·82	1·31
July	1·04	3·69	4·52	6·05	3·26	2·53	3·70	3·20	6·20	5·00	4·18	3·83
August	2·24	2·18	5·33	2·42	3·82	2·54	3·24	2·35	5·00	5·10	3·22	2·20
September ...	3·66	2·24	6·96	2·65	3·24	2·07	3·60	1·85	6·00	3·00	5·02	2·36
October	·87	1·15	2·16	3·25	1·06	1·33	1·57	1·07	3·00	4·00	1·87	1·85
November ...	2·00	·62	5·64	1·22	2·36	·87	2·23	·98	5·20	2·00	4·88	·42
December ...	1·68	1·61	7·17	4·18	2·21	3·04	2·05	2·34	5·00	3·40	4·44	1·71
Totals	22·14	24·50	56·89	49·45	29·19	27·55	26·43	23·60	55·40	45·50	41·83	28·53

ENGLAND AND WALES.

Division IX.—Yorkshire (*continued*).										Div. X.—Northern Co.'s.			
York.—East Riding.				York.—North Riding.						Durham.			
Beverley Road, Hull.		Holme, on Spalding Moor.		Malton.		Beadlam Grange.		Scarborough.		Darlington.		Stubb House, Winston.	
3 ft. 10 in. 11 ft.		3 ft. 0 in. 30 ft.		1 ft. 0 in. 73 ft.		0 ft. 6 in. 192 ft.		1 ft. 0 in. 180 ft.		4 ft. 0 in. 140 ft.		0 ft. 9 in. 458 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1·51	2·84	1·45	2·24	2·31	3·10	2·47	3·93	1·65	4·41	3·47	5·50	2·64	2·96
1·96	1·09	2·02	1·23	2·29	1·01	2·90	1·24	1·76	·81	1·59	1·86	2·16	1·34
1·72	1·86	1·62	1·67	2·34	1·77	2·48	1·65	1·89	1·52	3·78	4·60	2·30	1·92
·85	2·45	·94	3·13	1·35	3·86	1·15	3·78	2·21	1·76	2·69	3·92	2·24	2·27
1·33	1·47	·91	1·28	·82	1·97	1·37	1·74	·91	2·52	1·20	3·72	·67	2·16
3·40	1·38	2·63	2·09	2·87	1·89	2·22	1·53	2·55	1·84	2·87	2·63	2·72	1·08
2·74	3·12	3·01	3·50	3·85	4·35	4·16	3·28	3·50	4·42	5·94	4·11	3·73	2·65
5·17	2·02	3·03	4·07	3·46	3·37	4·13	4·25	5·86	2·40	3·62	4·51	2·67	2·07
5·34	1·69	3·89	2·15	4·78	2·28	3·95	2·51	3·42	2·60	7·24	2·60	4·83	1·28
2·50	2·09	2·51	1·72	2·78	1·69	2·53	1·92	2·80	3·29	2·69	1·85	1·12	1·03
2·75	1·36	2·59	1·37	2·28	1·27	2·16	1·32	2·75	·89	1·92	1·19	1·99	0·00
1·93	2·73	1·95	2·35	2·49	2·49	2·49	1·19	2·14	2·87	1·70	4·30	2·26	1·89
31·20	24·10	26·55	26·80	31·62	29·06	32·01	28·34	31·44	29·33	38·71	40·79	29·33	20·65

Division X.—Northern Counties (*continued*).													
Northumb.'d (*continued*).		Cumberland.											
Lilburn Tower, Alnwick.		Stonethwaite, Borrowdale.		Seathwaite.		Whinfell Hall, Cockermouth.		Keswick.		Cockermouth.		Mire House, Bassenthwaite.	
6 ft. 0 in. 290 ft.		0 ft. 6 in. 330 ft.		1 ft. 0 in. 422 ft.		2 ft. 0 in. 266 ft.		1 ft. 0 in. 270 ft.		0 ft. 6 in. 158 ft.		0 ft. 7 in. 310 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2·46	4·74	19·09	8·65	25·99	15·66	9·69	5·12	10·65	5·97	8·56	4·30	10·43	4·88
3·09	·82	14·54	11·52	19·17	17·05	6·08	3·66	6·99	5·70	4·44	3·32	5·72	4·53
3·67	2·32	7·92	6·75	13·05	8·32	3·83	2·37	5·02	3·51	2·44	1·53	3·39	2·73
2·00	2·44	4·84	12·87	5·97	16·92	1·89	5·52	2·85	7·10	1·00	4·72	2·09	5·35
1·01	1·77	3·40	2·84	5·06	5·25	2·00	2·38	1·04	2·89	1·96	1·59	1·89	2·21
·87	1·50	5·70	3·84	6·57	4·90	2·72	1·65	2·38	1·74	2·48	1·60	2·52	1·62
5·26	5·17	5·60	8·30	11·18	10·43	4·36	4·77	5·00	6·17	4·51	3·37	5·33	4·25
3·35	1·55	10·86	6·83	12·69	13·05	5·37	4·27	7·10	2·59	3·45	3·67	5·30	2·50
2·10	1·62	17·83	9·85	21·35	12·47	9·11	6·27	7·96	4·35	6·91	5·05	8·20	5·25
1·21	1·24	7·69	10·97	9·62	13·67	3·58	5·53	3·57	6·40	2·55	4·31	2·95	4·68
3·10	·26	14·04	1·71	23·08	2·55	7·97	·84	8·95	·92	6·89	1·01	7·81	·86
1·94	3·18	19·60	7·14	25·39	13·04	6·88	4·35	9·30	4·80	5·58	3·88	6·90	4·01
30·06	26·61	131·11	91·27	179·12	133·31	63·48	46·73	70·81	52·14	50·77	38·35	62·53	42·87

ENGLAND AND WALES.

Division X.—Northern Counties (*continued*).

	Cumberland (*continued*).				Westmoreland.							
Height of Rain-gauge above	Silloth.		Scaleby, Carlisle.		Kendal.		Lesketh How, Ambleside.		The How, Troutbeck.		Edenhall, Penrith.	
Ground	3 ft. 0 in.		0 ft. 8 in.		4 ft. 6 in.		3 ft. 0 in.		1 ft. 2 in.		1 ft. 0 in.	
Sea-level......	28 ft.		120 ft.		149 ft.		200 ft.		470 ft.		320 ft.?	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	4·69	2·53	3·64	3·63	7·33	6·56	13·90	10·78	12·40	12·14	5·28	1·50
February ...	3·42	2·01	3·20	2·14	6·16	5·23	10·92	11·55	9·51	11·66	3·75	2·60
March	1·39	·63	1·86	·81	3·53	2·11	6·94	3·97	5·75	5·43	1·85	1·70
April	·84	2·80	·94	4·07	1·61	5·76	2·97	9·01	3·21	13·53	1·60	3·80
May	1·37	2·18	1·30	2·02	1·86	2·42	2·36	3·46	1·93	4·01	1·35	1·75
June	2·20	1·20	1·84	1·41	3·01	2·17	3·82	1·72	3·55	1·77	1·65	1·65
July	3·60	2·77	3·42	3·47	3·17	3·79	4·26	4·39	4·50	4·06	3·15	4·10
August	3·55	2·61	3·97	1·35	5·22	3·49	7·97	5·91	6·53	4·48	3·45	2·40
September ...	5·31	3·84	5·14	2·93	9·77	5·22	13·93	6·45	14·48	6·44	5·17	2·70
October	2·07	2·98	1·70	2·70	2·92	5·00	4·95	9·74	5·93	6·63	1·85	2·50
November ...	4·33	·92	3·90	·20	8·39	·67	13·78	1·62	15·00	·74	3·77	1·10
December ...	3·99	2·01	3·39	2·33	7·42	4·89	14·01	7·96	15·90	6·94	3·88	2·10
Totals	36·76	26·48	34·30	27·06	60·39	47·31	99·81	76·56	98·69	77·83	36·75	27·90

Division XI.—Monmouth, Wales, and the Islands (*continued*.)

	Pembroke.				Cardigan.				Brecknock.		Radnor.	
Height of Rain-gauge above	Pembroke Dock.		Haverford-west.		Lampeter.		Frongoch.		Pen-y-Maes, Hay.		Cefnfaes, Rhayader.	
Ground	4 ft. 0 in.		2 ft. 0 in.		5 ft. 0 in.		4 ft. 0 in.		1 ft. 0 in.		2 ft. 0 in.	
Sea-level......	30 ft.		60 ft.		420 ft.		885 ft.		400 ft.		880 ft.	
	186	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ...	5·44	Return not received.	7·90	7·11	7·76	5·68	10·75	7·78	4·01	4·73	7·42	4·96
February ...	3·83		5·41	5·97	5·57	2·79	5·22	4·50	4·26	2·56	6·03	3·53
March	4·24		5·39	5·68	5·30	2·89	5·21	1·73	3·81	4·23	3·93	4·03
April	2·02		2·21	7·78	1·35	4·67	·98	8·03	2·45	3·21	1·33	5·93
May	1·55		1·36	4·14	·83	2·74	2·09	2·23	4·58	4·14	1·18	3·46
June	1·93		3·97	·71	4·09	·75	8·94	1·49		·66	3·87	·55
July	1·55		1·56	3·01	1·59	5·14	3·03	6·10	1·53	3·21	2·41	4·53
August	2·45		5·00	3·45	3·97	1·36	5·73	3·15	3·29	1·53	4·21	1·24
September ...	7·92		9·51	3·54	10·54	3·16	8·13	6·03	6·38	1·93	6·98	2·96
October	2·45		2·74	8·54	2·33	8·11	3·25	7·83	2·23	4·39	3·14	5·33
November ...	4·06		5·24	2·21	4·03	·95	5·08	3·74	1·75	·74	4·86	1·49
December ...	5·09		4·68	3·73	3·50	4·39	6·33	4·00	2·36	1·35	5·69	2·95
Totals	42·53	...	54·97	55·87	50·86	42·63	64·74	56·61	36·65	32·68	51·05	40·96

ENGLAND AND WALES.

Division X. (*continued*).		Division XI.—Monmouth, Wales, and the Islands.											
Westmoreland (*cont.*).		Monmouth.						Glamorgan.		Carmarthen.			
Appleby.		Abercarn.		Blaina, Tredegar.		Abergavenny.		Swansea.		Carmarthen.		Rhydwen.	
1 ft. 0 in. 442 ft.		1 ft. 0 in. 450 ft.		0 ft. 9 in. 1100 ft.		1 ft. 3 in. 220 ft.		16 ft. 0 in. 30 ft.		0 ft. 5 in. 78 ft.		1 ft. 0 in. 150 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
6·60	4·89	8·92	7·95	8·96	8·32	5·86	6·00	4·21	4·12	5·59	5·17	7·38	6·53
3·21	2·34	7·07	4·28	7·42	5·42	4·07	2·83	3·32	2·51	4·76	3·12	4·11	5·44
1·66	2·41	3·84	5·34	4·37	4·91	4·13	4·45	2·67	2·56	4·82	3·37	4·93	4·30
1·97	4·47	3·30	5·03	3·43	5·58	2·21	3·00	1·43	3·60	1·85	4·48	1·63	5·64
·86	2·18	1·06	4·70	1·80	6·00	·77	5·25	·66	3·04	1·28	3·90	1·11	2·85
2·24	1·60	3·59	1·46	4·13	1·44	3·26	·76	2·25	1·07	4·35	·66	2·83	·45
2·75	4·51	1·62	5·13	2·08	3·86	1·27	3·20	·89	1·87	·95	2·31	·51	2·18
4·64	2·93	4·51	1·76	4·25	1·85	2·70	·81	3·58	1·91	6·00	2·50	4·41	1·94
5·77	2·60	13·39	3·31	9·84	3·95	7·81	1·79	8·37	2·05	7·92	3·40	7·86	3·71
1·73	3·55	3·74	5·20	2·92	6·37	2·74	4·27	1·53	5·50	2·31	7·03	2·33	7·72
3·46	·66	3·41	1·12	3·25	2·35	1·36	1·04	1·38	1·54	4·36	1·52	4·67	1·51
4·47	2·41	6·00	2·76	5·77	1·81	2·43	1·43	2·91	2·36	4·05	4·58	4·23	3·79
39·36	34·55	60·45	48·04	58·22	51·86	38·61	34·83	33·20	32·13	48·24	42·04	46·00	46·06

Division XI.—Monmouth, Wales, and the Islands (*continued*).													
Flint.				Denbigh.		Merioneth.		Carnarvon.				Isle of Man.	
Hawarden.		Maes-y-dre, Holywell.		Llandudno.		Brithdin, Dolgelly.		Plas Brereton, Carnarvon.		Llanfairfechan.		Calf of Man.	
1 ft. 0 in. 268 ft.		5 ft. 0 in. 400 ft.		0 ft. 6 in. 99 ft.		1 ft. 0 in. 500 ft.		1 ft. 0 in. 25 ft.		0 ft. 8 in. 150 ft.		0 ft. 10 in. 325 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2·36	2·87	·39	2·30	3·60	3·62	10·60	6·90	6·12	5·09	5·79	4·21	2·93	3·85
2·88	1·36	1·30	1·56	3·15	1·75	4·06	2·13	3·64	1·99	4·39	2·26	2·04	·89
1·80	2·29	·63	1·10	1·73	2·02	5·86	3·41	2·72	2·28	3·74	2·77	1·69	1·53
·82	3·36	1·42	2·70	·44	3·14	1·15	7·12	1·05	3·85	·57	4·16	·63	1·54
·98	1·83	1·40	1·44	1·50	1·61	1·97	3·31	2·01	1·42	2·56	1·67	·63	1·15
2·85	·73	3·48	·61	3·86	·39	5·23	·95	5·37	·76	4·80	·53	2·59	·36
2·49	4·49	2·34	4·24	1·75	5·26	2·68	7·60	·85	3·63	1·99	5·32	1·68	3·13
3·63	1·11	3·54	1·08	2·89	1·26	5·85	·93	3·08	2·09	2·45	1·21	2·28	1·97
5·53	1·34	5·55	1·74	5·16	2·30	8·96	3·53	7·97	3·77	6·66	2·59	2·26	1·64
1·43	3·99	1·47	3·68	2·10	4·97	3·08	9·91	2·14	5·35	2·08	5·71	1·43	2·77
3·01	1·07	3·41	1·54	4·22	1·12	6·68	1·74	3·83	1·69	4·37	1·47	3·26	·82
2·04	2·97	2·00	2·78	3·15	4·54	5·59	6·11	3·91	3·68	4·13	2·96	2·22	2·27
29·82	27·41	26·93	24·77	33·55	31·98	61·71	53·64	42·69	35·60	43·53	34·86	23·64	21·92

ENGLAND AND WALES. SCOTLAND.

Division XI.—Monmouth, Wales, and the Islands (continued).	Isle of Man (continued).				Channel Islands.						Div. XII.—S. Counties. Wigton.	
Height of Rain-gauge above	Douglas.		Point of Ayr.		Guernsey.		Millbrook, Jersey.		Alderney.		S. Cairn, Stranraer.	
Ground	0 ft. 3 in.		3 ft. 4 in.		12 ft. 0 in.		0 ft. 6 in.		10 ft. 0 in.		0 ft. 4 in.	
Sea-level......	....		27 ft. ?		204 ft.		50 ft.		48 ft.		209 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ...	8·20	4·60	3·82	1·70	7·91	5·48	4·11	4·46	4·11	4·46	6·35	4·35
February ...	5·20	4·30	2·77	1·15	5·78	2·21	3·30	2·97	3·30	2·97	3·60	3·35
March	3·40	3·40	3·00	1·09	2·49	6·44	2·67	5·15	2·67	5·15	4·40	2·15
April	1·30	5·50	·44	3·02	2·17	2·07	1·72	2·00	1·72	2·00	1·70	6·60
May	1·00	2·80	1·27	2·67	2·46	2·23	1·21	1·65	1·21	1·65	1·55	4·15
June	2·70	·60	2·49	·36	1·61	·83	2·05	1·12	2·05	1·12	3·05	1·80
July	2·70	3·10	2·42	4·97	1·63	4·18	1·77	4·56	1·77	4·56	4·35	5·70
August	3·80	3·50	2·66	2·90	3·76	1·06	3·68	1·66	3·68	1·66	5·50	4·65
September ...	6·70	3·50	4·47	2·26	9·39	3·91	7·76	1·07	7·76	1·07	5·80	5·05
October	2·90	5·90	1·56	3·78	1·29	4·29	·82	4·93	·82	4·93	3·10	6·00
November ...	7·40	·90	3·86	·56	2·70	·89	2·49	2·69	2·49	2·69	6·00	2·65
December ...	7·50	5·50	3·43	2·39	3·23	3·48	3·51	2·31	3·51	2·31	4·70	4·40
Totals	52·80	43·60	32·19	26·85	44·42	37·07	35·09	34·57	35·09	34·57	50·10	50·85

Division XIII.—South-Eastern Counties (continued).	Berwick.		Haddington.				Edinburgh.					
Height of Rain-gauge above	Thirlestane.		Yester.		East Linton.		Glencorse.		Inveresk.		Charlotte-sq., Edinburgh.	
Ground	0 ft. 3 in.		1 ft. 0 in.		0 ft. 3 in.		0 ft. 6 in.		2 ft. 0 in.		0 ft. 6 in.	
Sea-level......	558 ft.		425 ft.		90 ft.		787 ft.		60 ft.		230 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ...	4·50	6·70	3·45	3·75	2·06	4·31	4·28	No return.	2·14	4·03	2·49	5·62
February ...	3·80	1·65	3·80	2·35	2·30	·70	4·60		3·14	2·30	3·50	1·68
March	7·90	1·60	2·60	4·17	2·18	1·29	1·80		2·08	1·80	1·85	1·17
April	1·20	2·60	2·20	3·40	1·00	1·19	2·20		1·89	3·35	1·37	2·71
May	·75	1·80	1·95	2·77	·68	1·44	2·00		1·50	2·85	1·50	3·71
June	1·50	1·50	2·20	3·20	·84	1·44	1·25		1·02	2·52	1·27	2·80
July	2·70	4·20	...	6·25	3·96	6·96	4·80		4·52	6·23	3·34	5·63
August	3·60	1·00	2·60	4·50	2·16	·96	3·75		3·58	2·44	2·73	2·64
September ...	2·40	2·00	3·65	2·15	2·04	·95	3·65		2·69	1·49	2·45	1·53
October	2·30	1·50	2·15	...	1·08	·73	1·50		1·10	2·32	1·23	1·50
November ...	2·90	·50	3·19	...	1·98	·33	3·55		2·57	·63	2·71	·74
December ...	3·10	2·20	3·27	2·05	1·22	1·01	5·15		2·75	1·15	2·29	1·26
Totals	36·65	27·25	...	...	21·50	21·31	38·53	...	28·98	31·11	26·73	31·04

SCOTLAND.

Division XII.—Southern Counties (*continued*).										Division XIII.—South-Eastern Counties.			
Kirkcudbright.				Dumfries.						Selkirk.		Peebles.	
Little Ross.		Slogarie, Castle Douglas.		Cargen.		Drumlanrig.		Wanlockhead.		Bowhill, Selkirk.		N. Esk Reservoir, Penicuick.	
3 ft. 3 in. 130 ft.		0 ft. 6 in. 800 ft.		0 ft. 3 in. 80 ft.		..........: 191 ft.		0 ft. 4 in. 1330 ft.		4 ft. 0 in. 537 ft.		0 ft. 6 in. 1150 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4·23	2·28	...	6·54	9·64	4·00	10·50	7·80	13·06	6·23	6·38	3·65	5·10	4·15
1·83	2·30	...	4·85	4·43	2·36	5·50	7·90	5·36	6·43	4·60	1·97	4·55	3·45
2·00	·90	...	3·35	3·34	2·34	3·40	4·10	4·86	3·49	1·89	2·43	2·05	1·05
·77	2·67	2·81	6·66	1·28	3·64	1·70	8·50	3·36	6·26	1·10	2·88	2·30	4·25
1·24	2·20	2·54	2·91	1·36	1·97	1·50	3·80	1·52	1·95	1·51	2·59	2·25	2·70
1·21	·95	3·75	2·62	2·46	1·06	2·50	2·50	2·48	3·74	1·50	1·57	1·55	2·15
3·17	1·79	3·31	4·09	3·54	3·02	2·50	5·40	3·83	4·40	3·16	5·18	3·75	5·10
2·23	1·91	6·43	4·79	3·54	2·56	4·10	4·00	6·66	4·43	3·65	3·68	3·85	2·05
4·50	1·36	8·00	4·02	6·44	3·96	6·70	4·00	7·85	6·13	3·76	1·96	2·85	2·70
1·75	3·60	8·35	6·62	3·50	3·71	3·50	5·80	4·71	7·87	1·79	2·97	2·25	2·45
3·44	·37	6·12	1·25	5·68	·46	4·40	1·10	4·86	1·59	1·40	·25	3·95	·75
2·33	1·32	8·06	4·22	4·96	2·02	5·90	3·60	8·34	6·13	2·45	2·25	4·50	2·70
8·70	21·65	...	51·92	50·17	31·10	52·20	58·50	66·89	58·65	33·19	31·38	38·95	33·50

Division XIV.—South-Western Counties.													
Lanark.										Ayr.			
Newmains, Castle Douglas.		Auchinraith, Hamilton.		Glasgow Observatory.		Bailliestown.		Hill End House, Shotts.		Girvan.		Auchendrane, Ayr.	
0 ft. 2 in. 783 ft.		4 ft. 9 in. 150 ft.		0 ft. 0 in. 200 ft.		0 ft. 3 in. 230 ft.		7 ft. 0 in. 620 ft.		0 ft. 6 in. 15 ft.		2 ft. 3 in. 94 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
·56	5·66	4·33	2·85	7·61	3·98	6·76	4·18	4·46	1·98	10·30	3·60	8·30	4·28
·91	4·57	3·70	2·93	6·16	3·43	5·29	3·39	3·16	3·18	5·08	3·60	5·30	3·94
·40	2·46	1·05	1·02	1·91	1·61	1·61	1·88	1·33	·91	6·18	2·30	2·13	1·07
·79	4·65	1·60	3·25	1·49	5·12	1·67	5·31	1·20	3·27	1·00	5·78	·77	4·64
·31	2·02	1·28	2·00	1·36	3·46	1·81	3·41	1·65	2·50	1·85	2·20	1·94	1·58
·42	2·02	1·82	1·60	2·22	2·30	2·49	2·72	1·19	2·70	2·35	2·20	2·17	3·22
·59	5·16	3·75	4·12	4·00	4·78	5·31	5·97	3·93	3·34	3·65	5·70	3·32	5·48
·00	2·14	3·50	2·72	5·45	5·13	4·50	4·46	3·74	3·39	5·03	3·00	4·86	3·20
·46	4·45	3·84	2·83	5·67	3·73	6·29	4·23	4·37	3·35	5·50	3·50	5·91	4·33
·11	3·91	1·60	3·63	3·07	4·65	2·58	4·81	1·94	3·08	2·60	5·23	2·65	5·18
·21	·95	2·94	·78	4·39	1·26	4·82	1·55	3·52	·68	6·90	2·48	6·17	1·09
·02	3·38	4·78	2·04	6·01	4·38	6·19	3·50	4·40	2·65	5·20	3·00	6·32	4·10
·78	41·87	34·19	29·77	49·34	44·33	49·32	45·41	34·89	31·03	55·64	42·59	49·84	42·11

SCOTLAND.

Division XIV.—South-Western Counties (*continued*).									Division XV.—West Midland Counties.			
	Ayr (*continued*).		Renfrew.						Dumbarton.			
Height of Rain-gauge above	Mansfield, Largs.		Nither Place, Mearns.		Kilbarchan, Paisley.		Greenock.		Balloch Castle.		Arddarock, Loch Long.	
Ground	0 ft. 6 in.		0 ft. 5 in.		0 ft. 8 in.		0 ft. 6 in.		0 ft. 4 in.		1 ft. 0 in.	
Sea-level......	30 ft.		350 ft.		350 ft.		50 ft.		90 ft.		80 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January......	9·00	3·70	8·38	4·63	12·20	6·50	12·55	8·93	9·22	4·76	14·00	7·3
February ...	5·30	3·60	5·25	6·12	8·05	6·00	9·54	6·31	7·78	4·83	9·44	8·5
March	3·90	2·70	2·25	1·38	2·80	1·40	4·15	2·93	3·10	2·60	6·04	4·4
April	1·90	7·30	1·50	7·00	2·20	7·90	2·45	8·10	1·84	6·30	5·02	9·8
May	1·70	3·40	1·87	3·12	1·80	3·75	1·97	4·12	1·50	3·60	2·50	3·5
June	2·60	2·10	2·00	1·38	3·00	2·60	3·50	2·72	2·83	1·72	2·03	3·3
July	2·70	2·90	5·75	5·12	4·50	5·90	3·85	5·51	4·45	3·90	3·16	4·4
August	6·20	4·40	5·00	4·63	6·90	5·40	7·25	4·42	7·37	5·35	10·27	5·4
September..	5·60	3·50	6·50	5·25	8·70	6·30	8·04	5·12	6·00	4·93	10·10	5·5
October	4·30	4·90	3·25	6·00	6·00	7·30	5·27	7·82	4·21	5·50	4·81	8·8
November ...	5·00	1·60	5·38	1·62	7·55	1·40	5·62	1·84	5·66	2·20	9·00	2·5
December ...	6·50	3·90	7·12	4·50	10·50	5·70	9·72	4·62	7·63	4·31	12·98	6·4
Totals	54·70	44·00	54·25	50·75	74·20	60·15	73·91	62·44	61·59	50·00	89·35	70·5

Division XV.—West Midland Counties (*continued*).												
	Argyll (*continued*).											
Height of Rain-gauge above	Castle Toward.		Kilmory, Lochgilphead.		Fladda.*		Inverary Castle.		Lismore.		Hynish.	
Ground	4 ft. 0 in.		0 ft. 4 in.		0 ft. 6 in.		0 ft. 0 in.		3 ft. 4 in.		0 ft. 0 in.	
Sea-level......	80 ft.		100 ft.		20 ft. ?		30 ft.		37 ft.		....	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January......	10·26	5·52	10·90	6·50	11·50	7·30	12·00	8·00	7·88	4·86	15·47	6·5
February ...	5·88	5·91	8·20	7·60	6·40	7·90	6·00	8·00	5·13	5·01	8·03	5·3
March	3·82	1·93	4·30	2·10	7·50	1·90	4·00	3·00	2·80	·85	5·61	2·3
April	1·80	7·22	2·50	9·10	2·40	11·00	3·00	9·00	1·72	6·06	3·01	7·9
May	2·04	4·36	1·80	3·10	2·90	3·00	1·00	1·00	1·69	2·97	1·86	2·6
June	2·42	2·64	3·10	2·80	4·80	4·30	3·00	4·00	1·45	2·33	2·37	2·8
July	3·69	3·66	3·40	4·10	5·10	3·30	3·00	3·00	3·10	3·90	2·82	3·4
August	8·34	4·23	6·40	4·30	8·90	?25·50	8·00	6·00	6·41	5·19	3·60	6·4
September...	7·30	5·52	8·60	5·50	9·90	?11·50	10·00	5·00	8·31	3·42	7·08	2·4
October	3·83	7·89	5·80	9·60	6·90	?15·80	5·00	10·00	4·13	7·14	4·88	11·7
November ...	5·84	1·33	7·10	3·70	8·90	6·70	8·00	3·00	4·53	1·21	9·28	3·3
December ...	8·63	4·82	11·30	6·80	10·60	9·10	14·00	8·00	6·68	3·44	14·71	7·5
Totals	63·85	55·03	73·40	65·20	85·80	107·30?	77·00	68·00	53·83	46·38	78·72	62·5

SCOTLAND.

Division XV.—West Midland Counties (*continued*).

Stirling.				Bute.		Argyll.							
Polmaise, Stirling.		Ben Lomond.		Pladda.		Devaar, Campbeltown.		Rhinns of Islay.		M'Arthur's Head.		Stonefield.	
1 ft. 0 in. 12 ft.		0 ft. 6 in. 1800 ft.		3 ft. 6 in. 55 ft.		3 ft. 4 in. 75 ft.		3 ft. 0 in. 74 ft.		0 ft. 4 in. 106 ft.		1 ft. 3 in. 90 ft.	
…866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
…n.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
5·40	4·80	11·10	Spoilt by snow.	6·97	1·44	9·67	4·21	5·22	3·18	12·50	5·80	13·40	7·40
…5·50	3·80	4·20		4·36	3·70	5·39	4·57	3·94	2·92	8·70	7·90	8·60	8·20
…2·50	1·50	8·90		2·38	1·20	2·80	2·26	2·10	1·11	4·00	1·90	5·00	2·10
…·00	6·00	5·20		1·29	6·34	1·37	5·39	·95	3·93	2·50	9·20	2·68	10·30
·80	3·60	2·30	4·10	1·44	2·86	1·89	2·16	1·39	2·15	2·10	3·60	2·50	3·52
…·00	2·20	5·50	4·20	2·02	2·00	2·46	2·67	1·67	1·86	2·60	3·50	3·45	2·22
…·80	3·60	5·60	7·30	2·04	5·56	2·86	3·68	2·29	2·86	5·70	4·30	4·20	3·80
…·50	3·50	13·20	8·90	4·96	3·20	5·86	2·65	3·55	3·18	9·20	5·30	9·00	4·22
…·70	2·80	13·80	9·60	5·40	4·99	6·48	3·53	4·21	1·42	9·90	4·80	9·20	7·15
…·50	5·00	7·90	14·60	1·81	5·35	1·79	6·68	2·91	5·31	4·40	11·40	6·30	11·94
…·20	1·10	8·50	3·10	4·90	1·00	5·08	2·52	5·38	1·12	8·00	2·60	8·30	3·30
…·60	2·50	13·90	7·30	6·59	2·94	6·02	4·53	5·10	2·74	11·00	7·20	13·38	8·40
…·50	40·40	100·10	...	44·16	40·58	51·67	44·85	38·71	31·78	80·60	67·50	86·01	72·55

…iv. XV.—(*continued*).				Division XVI.—East Midland Counties.									
Argyll (*continued*).				Clackmannan.		Kinross.		Fife.		Perth.			
…orran, …och Eil.		Ardnamurchan.		Dollar.		Loch Leven Sluice.		Nookton Leven.		Kippenross, Dunblane.		Deanston.	
…ft. 4 in. 14 ft.		3 ft. 6 in. 82 ft. ?		0 ft. 4 in. 170 ft.		0 ft. 10 in.		0 ft. 6 in. 80 ft.		0 ft. 4 in. 100 ft.		0 ft. 2 in. 130 ft.	
…66.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
…	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
…175	6·10	8·23	3·50	3·85	4·03	3·30	4·00	2·80	4·11	5·60	3·30	6·96	4·01
…115	11·30	3·67	3·49	6·40	3·88	4·30	1·80	4·10	1·62	5·10	2·70	5·91	4·27
…75	1·60	2·78	·71	3·78	2·10	3·60	1·30	2·02	1·18	2·70	·70	2·75	2·07
…31	11·50	1·20	5·80	1·81	5·75	1·80	3·30	1·45	2·83	1·40	3·90	2·11	5·53
…65	1·20	1·37	1·86	·85	3·38	1·00	3·90	1·50	4·47	·40	2·10	1·11	3·89
…50	4·45	1·39	2·21	2·58	3·14	2·00	2·00	1·35	1·96	·90	0·00	2·58	2·20
…25	4·20	4·25	2·75	4·04	4·79	3·20	4·70	2·87	6·49	1·30	3·00	3·27	4·18
…45	6·10	3·99	3·34	6·33	5·38	4·30	3·00	3·42	2·04	4·20	3·20	6·14	4·48
…30	7·55	6·61	3·10	4·08	3·35	4·10	1·80	2·73	2·20	1·50	1·40	5·89	4·72
…30	12·55	4·18	6·40	3·36	5·16	3·30	3·20	1·89	1·99	2·10	3·20	3·28	4·33
…55	1·30	5·77	1·10	3·65	1·29	3·00	·30	2·12	·43	2·50	·50	3·35	1·22
…10	8·45	7·56	3·19	6·10	1·62	3·80	1·70	2·94	1·44	5·10	1·70	6·37	3·25
…6	76·30	51·00	37·45	46·83	43·87	37·70	31·00	29·19	30·76	32·80	25·70	49·72	44·15

SCOTLAND.

Division XVI.—East Midland Counties (*continued*).

Perth (*continued*).

Height of Rain-gauge above Ground ...... Sea-level......	Loch Katrine. 0 ft. 6 in. 830 ft.		Auchterarder. 2 ft. 3 in. 162 ft.		Stronvar, Loch Earn Head. 0 ft. 5 in. 463 ft.		Trinity Gask. 0 ft. 1 in. 133 ft.		Scone Palace. 2 ft. 6 in. 80 ft.		Stanley. 1 ft. 0 in. 200 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ...	12·60	6·10	3·35	3·60	14·95	5·75	5·10	5·86	3·68	4·03	3·65	3·83
February ...	11·50	8·20	3·45	2·70	11·05	9·65	3·90	2·66	Rain register burnt along with gardener's bothy.	1·70	3·08	2·05
March	5·50	3·20	2·80	2·35	8·67	3·10	3·75	2·20		1·76	2·76	2·15
April	5·70	10·60	2·60	4·60	5·80	9·52	2·20	3·46		1·76	1·06	2·80
May	1·90	4·00	·65	3·40	1·60	3·30	·80	3·77		3·50	·53	3·23
June	3·70	3·20	2·00	2·55	3·92	3·20	2·00	3·50		·33	1·10	1·30
July	4·10	6·70	2·30	5·35	3·35	6·20	3·07	3·93		7·05	3·46	5·12
August	9·00	4·90	4·99	2·30	7·60	4·55	4·55	2·31		2·95	3·60	2·10
September ...	8·60	7·40	5·00	1·70	11·95	4·00	5·62	1·26		1·35	3·97	1·56
October	6·80	9·10	2·20	2·85	6·45	9·30	2·07	2·97		1·68	2·27	2·55
November ...	7·50	2·60	2·30	·50	6·25	2·30	2·10	·28		·43	1·79	·31
December ...	12·90	7·40	4·45	·95	12·70	5·70	4·76	1·52		·62	3·51	·93
Totals	89·80	73·40	36·09	32·85	94·29	66·57	39·92	33·72	....	27·16	30·78	27·93

Division XVII.—North-Eastern Counties (*continued*). / Div. XVIII.—North-Western Counties.

	Aberdeen (*continued*).						Moray.		West Ross.		East Ross.	
Height of Rain-gauge above Ground ...... Sea-level......	Aberdeen. 0 ft. 4 in. 95 ft.		Castle Newe. 1 ft. 0 in. 915 ft.		Tillydesk, Ellon. 0 ft. 4 in. 349 ft.		Elgin Institution. 0 ft. 6 in. 33 ft.		Inverinate House, Loch Alsh. 3 ft. 0 in. 150 ft.		Cromarty. 3 ft. 4 in. 28 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	2·24	6·41	2·30	5·67	2·11	11·02	1·47	3·36	12·66	2·54	2·46	4·0[illegible]
February ...	2·52	1·37	3·39	1·17	4·78	1·73	2·06	2·00	8·02	9·35	3·12	1·2[illegible]
March	2·60	2·06	5·09	2·80	4·09	3·61	1·95	2·71	3·25	1·05	1·36	·9[illegible]
April	1·76	2·90	2·06	4·19	1·73	4·57	1·06	2·92	2·05	5·09	·75	2·1[illegible]
May	1·58	2·48	2·00	1·99	1·39	1·80	1·39	1·75	2·07	2·02	1·08	1·7[illegible]
June	1·29	1·19	1·80	1·44	2·08	1·49	...	2·47	1·78	4·60	1·05	1·3[illegible]
July	3·26	2·70	2·44	4·12	2·48	2·95	2·60	2·05	4·10	2·21	2·83	1·9[illegible]
August	2·99	3·52	3·29	1·84	2·62	2·73	3·09	2·04	5·50	3·70	2·20	1·4[illegible]
September ...	2·81	1·93	3·18	2·56	3·81	2·39	2·85	2·60	9·24	8·50	2·74	1·8[illegible]
October	2·72	1·93	1·59	3·54	2·84	2·81	2·00	3·26	4·56	10·01	1·10	2·61
November ...	2·14	·89	2·52	·92	3·36	1·39	2·96	1·15	8·56	2·30	3·17	·5[illegible]
December ...	3·05	2·39	4·16	3·08	3·99	3·92	4·35	2·46	12·70	9·35	3·88	1·6[illegible]
Totals	28·96	29·77	33·82	33·32	35·28	40·41	...	28·77	74·49	60·72	25·74	21·43

SCOTLAND.

Division XVI.—East Midland Counties (*continued*).						Division XVII.—North-Eastern Counties.									
Forfar.						Kincardine.								Aberdeen.	
Eastern Necropolis, Dundee.		Arbroath.		Montrose.		The Burn, Brechin.		Bogmuir, Fettercairn.		Banchory House.				Braemar.	
0 ft. 5 in. 164 ft.		2 ft. 0 in. 65 ft.		2 ft. 0 in. 200 ft.		0 ft. 6 in. 237 ft.		0 ft. 3 in. 200 ft.		0 ft. 4 in. 99 ft.				0 ft. 9 in. 1110 ft.	
1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.			1866.	1867.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.			in.	in.
2·60	4·90	2·57	5·51	1·68	1·58	3·50	4·50	3·00	Observer dead.	2·80	4·90			3·30	3·50
2·05	1·00	2·81	1·16	1·90	1·66	3·60	1·50	2·60		2·00	1·70			3·89	2·23
2·10	1·80	2·38	1·96	2·24	2·33	4·40	3·20	4·50		3·80	2·60			3·30	3·66
·35	2·10	1·28	2·48	1·19	2·69	1·70	4·20	1·10		1·60	4·00			2·16	3·84
1·00	3·60	1·57	3·51	1·47	3·36	·70	3·00	·70		1·30	3·20			1·06	2·35
1·25	1·00	1·03	1·37	1·32	1·69	1·70	1·50	1·20		1·50	1·10			1·49	2·01
2·75	7·00	2·20	4·69	2·37	4·69	2·20	5·10	1·80		3·10	3 40			2·75	4·83
2·55	2·00	2·15	2·78	2·05	2·89	3·00	2·70	2·50		3·60	3·20			3·48	1·93
2·80	1·50	3·01	1·75	3·01	2·17	3·60	2·60	3·50		3·30	2·40			3·43	2·56
1·65	2·05	2·03	2·05	2·91	2·80	3·20	3·40	3·60		3·00	2·80			2·54	3·99
1·60	·40	1·98	·48	2·24	·38	1·80	·50	1·60		2·40	1·10			3·35	·34
3·05	·95	2·97	1·14	2·41	1·41	3·90	1·90	3·00		4·10	3·00			3·71	1·12
23·75	28·30	25·98	28·88	24·79	27·65	33·30	34·10	29·10	...	32·50	33·40			34·46	32·36

Division XVIII.—North-Western Counties (*continued*).													
East Ross (*continued*).		Inverness.											
drossCastle, Alness.		Oronsay.		Raasay.		Barrahead.		Ushenish.		Culloden.		Island Glass.	
1 ft. 0 in. 450 ft.		0 ft. 6 in. 15 ft.		3 ft. 0 in. 80 ft.		3 ft. 0 in. 640 ft.		0 ft. 4 in. 157 ft.		3 ft. 0 in. 104 ft.		3 ft. 4 in. 50 ft.?	
866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
n.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·39	5·13	9·34	3·20	14·00	6·75	6·75	2·69	6·88	3·88	2·42	5·07	2·13	2·85
5·22	3·01	6·70	11·00	8·75	6·85	2·89	1·56	5·78	3·74	2·41	1·80	1·15	3·43
2·86	2·44	4·30	·90	3·85	1·95	1·93	1·44	3·52	1·29	1·29	·93	1·16	·92
1·56	4·45	1·90	8·80	5·05	4·40	1·30	1·89	1·12	6·73	1·01	2·93	·76	5·43
2·11	3·30	3·50	2·50	1·50	4·10	·96	2·02	1·22	2·98	1·34	1·59	·66	1·75
·07	2·58	1·55	5·00	2·00	4·15	1·14	1·99	1·48	2·27	·63	2·38	·25	2·25
1·93	3·17	·44	4·20	2·30	3·05	2·60	1·50	1·44	1·69	3·07	2·71	0·00	·72
·55	2·51	10·20	5·70	4·85	5·05	3·76	3·15	5·22	4·44	2·42	2·03	2·88	3·63
·17	2·78	6·10	8·80	9·40	8·90	3·47	2·45	4·97	5·87	3·07	1·31	5·14	3·47
·29	5·08	3·90	10·80	4·80	9·60	3·56	4·40	3·50	6·44	1·94	2·76	2·62	5·58
·22	1·51	11·10	1·70	7·00	4·35	2·24	1·20	5·81	3·15	2·64	·92	6·09	2·31
·72	3·31	11·20	8·80	13·40	8·60	5·01	2·52	8·34	5·95	3·86	1·88	7·26	3·82
·09	39·27	70·23	71·40	76·90	67·75	35·61	26·81	49·28	48·47	26·10	26·31	30·10	36·16

SCOTLAND.

Div. XVIII. (*continued*).			Division XIX.—Northern Counties.									
Inverness (*continued*).			Sutherland.						Caithness.			
Height of Rain-gauge above	Corrimony, Urquhart.		Dunrobin.		House of Tongue.		Cape Wrath.		Nosshead.		Holburnhead	
Ground ...... Sea-level......	0 ft. 4 in. 320 ft.		0 ft. 6 in. 6 ft.		0 ft. 1 in. 33 ft.		3 ft. 6 in. 355 ft.		3 ft. 4 in. 127 ft.		0 ft. 4 in. 60 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	5·34	4·50	2·04	2·60	4·60	3·50	5·00	2·71	·88	·60	2·75	2·2
February ...	3·00	4·50	2·73	2·60	7·50	4·00	5·39	2·18	2·61	·65	5·26	2·5
March	4·01	·70	1·00	1·00	3·40	5·00	1·41	·60	·88	·41	3·06	1·6
April	1·18	3·60	·62	2·80	1·40	2·90	1·01	3·58	·72	2·38	·99	3·5
May	1·40	2·30	·87	1·73	·90	·40	1·74	·84	1·08	1·02	1·63	·8
June	1·81	2·50	1·87	1·70	2·00	3·00	1·45	1·52	1·50	1·21	1·87	2·8
July	3·49	3·90	1·50	2·03	2·20	2·80	2·61	1·47	2·25	1·86	1·64	1·7
August	4·43	2·00	2·25	1·80	2·80	1·80	2·96	2·24	3·06	2·02	3·10	1·3
September ...	4·33	1·50	2·40	2·50	3·00	4·40	3·01	1·93	2·90	3·63	2·98	4·8
October	1·20	4·80	1·42	3·90	3·50	5·20	2·62	4·65	1·40	4·96	1·81	5·9
November ...	5·85	·90	5·35	1·10	10·00	2·00	7·04	2·46	5·66	·98	7·57	2·5
December ...	2·42	1·40	6·30	3·40	6·80	3·80	4·61	3·86	3·34	4·96	4·52	4·7
Totals	38·46	32·60	28·35	27·16	48·10	38·80	38·85	28·04	26·28	24·68	37·18	34·7

Division XX.—Munster (*continued*).											Div. XXI.—Leinster	
Kerry.			Waterford.				Clare.				Queen's Co	
Height of Rain-gauge above	Valentia.		Waterford.		Portlaw.		Killaloe.		Ennis.		Portarlingto	
Ground ...... Sea-level......	2 ft. 0 in. 30 ft.		4 ft. 0 in. 60 ft.		20 ft. 0 in. 50 ft.		5 ft. 0 in. 128 ft.		2 ft. 6 in. 35 ft.		1 ft. 1 in. 236 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	18
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	7·64	5·62	5·41	3·55	7·01	3·81	6·63	3·82	7·19	3·50	3·72	2·
February ...	4·39	4·87	2·70	2·93	3·22	3·55	5·51	5·21	3·94	4·25	3·00	2·
March	5·07	3·45	3·51	4·71	4·47	5·67	3·85	3·06	2·76	2·70	2·92	3·
April	3·52	4·97	2·41	3·03	2·66	3·55	2·05	6·43	2·19	3·49	1·64	2·
May	2·28	3·07	1·28	5·19	1·34	5·30	3·05	3·45	1·83	8·30	1·19	3·
June	3·30	2·05	3·93	·93	5·30	2·46	4·48	2·34	3·21	2·15	3·73	·
July	2·47	3·58	·85	5·02	·57	3·51	1·96	3·62	1·30	2·16	1·22	2·
August	5·57	4·67	3·47	3·85	3·56	3·42	4·55	4·70	5·40	Observer removed.	2·63	2·
September ...	5·79	5·86	3·96	2·53	4·46	2·23	6·47	3·14	5·30		4·16	1·
October	4·02	8·84	2·62	3·88	2·86	4·57	2·44	7·63	2·50		1·73	3·
November ...	4·26	1·47	2·34	2·20	2·65	1·51	4·77	1·57	3·26		1·89	2·
December ...	5·81	4·14	3·57	1·33	3·14	1·56	6·02	1·90	5·13		2·91	1·
Totals	54·12	52·59	36·05	39·15	41·24	41·14	51·78	46·87	44·01	...	30·74	29·

SCOTLAND. IRELAND.

Division XIX.—Northern Counties (continued).												Div. XX.—Munster.	
Caithness (continued).		Orkney.				Shetland.						Cork.	
Pentland Skerries.		Balfour Castle.		Sandwick.		Sumburghead.		Bressay.		East Yell.		Queen's College, Cork.	
3 ft. 3 in. 72 ft.		0 ft. 3 in. 50 ft.		2 ft. 0 in. 78 ft.		3 ft. 6 in. 265 ft.		0 ft. 4 in. 60 ft.		3 ft. 0 in. 176 ft.		6 ft. 0 in. 65 ft.	
66.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
n.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
·12	2·63	2·70	4·70	4·33	4·06	3·97	2·14	5·60	6·25	7·50	3·95	6·76	5·12
·44	2·32	3·80	3·50	5·63	4·03	2·73	2·56	3·90	3·71	3·53	4·17	2·76	2·59
·34	1·31	2·00	1·50	3·08	2·08	1·49	·84	2·33	2·08	3·07	2·22	3·97	8·03
·69	2·66	·60	3·70	1·21	4·20	·82	3·21	·71	4·00	1·71	3·83	2·70	3·30
·48	·91	1·50	·90	2·15	1·11	1·23	·73	1·60	·93	1·53	1·22	2·12	5·37
·74	1·28	2·10	1·60	1·87	1·79	·63	·85	·88	·94	1·35	1·45	3·74	1·57
·58	1·32	1·20	2·00	1·64	1·56	1·33	·82	1·84	·94	1·77	1·00	·44	2·93
·51	1·59	3·00	1·80	3·24	1·72	·88	2·55	1·47	1·98	1·82	2·31	3·61	2·29
·17	3·13	2·90	5·20	2·65	5·38	1·68	2·36	3·24	2·98	4·18	4·96	4·43	3·58
·15	4·63	2·20	5·70	2·75	6·66	2·67	4·20	4·03	5·18	5·32	6·68	3·21	4·66
·82	1·31	7·00	2·70	8·24	2·93	3·51	1·27	5·19	1·34	6·06	3·33	4·10	1·75
·29	3·53	4·00	4·30	4·76	3·87	3·02	3·89	4·54	4·80	5·45	6·69	4·22	1·50
·33	26·62	33·00	37·60	41·55	39·39	23·96	25·42	35·33	35·13	43·29	41·81	42·06	42·69

Division XXI.—Leinster (continued).								Division XXII.—Connaught.					
King's Co.				Wicklow.		Dublin.		Galway.				Sligo.	
rr Castle, rsonstown.		Tullamore.		Fassaroe, Bray.		Black Rock.		Cregg Park, Gort.		Queen's College, Galway.		Doo Castle.	
ft. 3 in. 200 ft.		3 ft. 0 in. 235 ft.		5 ft. 0 in. 250 ft.		29 ft. 0 in. 95 ft.		3 ft. 0 in. 120 ft.		6 ft. 0 in. 25 ft.		1 ft. 0 in.	
66.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
·14	1·70	3·30	2·41	4·28	4·35	2·41	3·07	6·79	3·49	8·96	4·77	6·55	4·40
·59	2·35	2·48	2·27	3·23	3·12	2·13	2·26	3·28	4·18	4·64	4·98	3·88	4·42
·43	1·92	2·20	2·62	4·99	6·58	4·27	4·47	2·85	3·09	3·29	3·37	2·93	2·70
·79	3·30	1·17	2·39	3·40	2·65	2·06	2·55	1·42	3·95	2·22	4·13	1·65	4·86
·14	2·99	1·00	3·36	·96	5·17	1·48	3·55	1·41	4·55	1·97	4·67	1·71	4·62
·57	1·02	2·62	·36	5·31	·80	4·06	·57	2·17	1·47	4·28	1·75	4·61	1·63
·91	3·82	·96	3·03	·91	3·03	·80	3·22	1·54	2·31	1·94	3·15	2·04	4·63
·78	2·69	2·78	3·01	2·50	1·11	1·92	1·09	3·73	3·31	5·11	4·49	5·39	2·78
·59	1·33	4·17	1·50	4·22	2·29	2·89	1·70	5·26	2·50	6·96	3·52	5·20	3·07
·17	4·61	1·47	3·59	4·18	3·13	2·64	2·28	2·03	5·56	2·60	5·29	2·40	7·27
·85	1·27	1·50	1·01	1·78	·63	1·28	·30	3·13	1·05	4·02	·74	4·25	·72
·54	1·11	2·71	1·40	2·45	2·42	1·60	1·05	5·13	1·47	5·60	2·23	4·60	2·97
3·50	28·11	26·36	27·45	38·21	35·28	27·54	26·11	38·74	36·93	51·59	43·09	45·21	44·07

IRELAND.

Div. XXII.—Connaught (continued).			Division XXIII.—Ulster.							
Sligo (continued).			Cavan.		Fermanagh.		Armagh.		Down.	
Height of Rain-gauge above	Hazlewood, Sligo.		Red Hills, Belturbet.		Florence Court.		Armagh Observatory.		Belfast.	
Ground	2 ft. 4 in.		0 ft. 9 in.		11 ft. 0 in.		30 ft. 0 in.		7 ft. 4 in.	
Sea-level......	47 ft.		....		300 ft.		238 ft.		68 ft.	
	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ...	5·59	4·13	5·16	4·15	10·05	5·40	Monthly returns not received.	4·03	3·53	3·47
February ...	3·39	3·30	2·92	2·38	2·46	3·65		4·41	2·87	2·67
March	2·41	3·22	3·28	2·37	3·66	4·55		2·21	3·43	2·15
April	1·73	3·98	2·97	5·59	2·34	5·68		4·25	1·58	3·55
May	1·86	4·32	1·54	3·59	·65	3·84		4·39	1·67	4·15
June	2·55	1·48	2·72	1·26	1·87	·67		1·00	2·53	·97
July	3·03	5·67	2·18	4·54	1·81	5·89		4·27	1·87	4·34
August	4·27	2·87	3·34	2·72	6·15	3·49		2·41	3·24	2·23
September ...	4·21	3·47	4·41	2·86	5·28	3·87		1·66	4·97	1·72
October	2·72	7·23	2·64	5·49	4·47	6·15		4·91	1·90	4·57
November ...	4·36	·54	3·66	1·15	6·34	1·08		·90	4·27	·76
December ...	5·17	3·35	4·28	1·95	5·57	2·69		2·29	3·70	2·10
Totals	41·29	43·56	39·10	38·05	50·65	46·96	37·90	36·73	35·56	32·68

APPENDIX.

On the Quantity of Rain measured in the Lake District.

By John Phillips, M.A., F.R.S., Professor of Geology.

[Proceedings of the Ashmolean Society, New Series, No. 1.]

In whatever direction we approach the district of the English Lakes, the quantity of rain, though not the number of rainy days, is found to increase continually, and near the mountains rapidly. By several years' observations, through the exertions of Dr. Miller, Mr. Fletcher, Mr. Marshall, Dr. Davy, Mr. Symons, and others, it is found that the mountain district of the Lakes receives more rain on the average than any other part of Great Britain. In the upper part of Borrowdale, at Seathwaite, 422 feet above the sea, about 130 or 140 inches of rain fall, on an average, in one year*; the maximum yet observed being 182·47 inches in 1861, the minimum 88·31 inches in 1855. Descending from this point along the course of Borrowdale, the quantities of rain diminish, and at Keswick only 59 inches are received, at an elevation of 270 feet.

As we ascend the mountain slope from Borrowdale toward Scawfell, the quantities increase; and at a place called Stye, 165 inches are received on the average—the maximum in 1866 being 224·56, and the minimum in 1853, 134·91. In the immediate vicinity, the quantity registered on the summit of Scawfell Pikes, 3200 feet above the sea, is on the average about 64 inches—maximum in 1864, 73·20; minimum in 1865, 49·12.

* Mr. Fletcher admits 134 inches as the most probable average.

Rainfall in each year from 1860 to 1867 inclusive, compared with the Mean of previous years.

ENGLAND AND WALES.

Division	Station	County	Average, 1850–59	Average, 1850–59 +5 p.c. [illegible]	1860.	1861	1862	1863.	1864.	1865.	1866.	1867	Average, 1860–67.	Difference from average of 50 years.
II.	Tong Sittingbourne	Kent	24·03	25·23	31·21	19·16	26·45	21·61	19·96	33·98	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Infirmary, Chichester	Sussex	26·67	28·00	37·44	25·15	27·47	25·08	23·25	35·68	[illegible]	[illegible]	[illegible]	+ [illegible]
"	[illegible]grove "	"	32·23	33·84	42·00	28·67	32·35	30·45	24·67	38·45	36·66	29·48	32·841	− ·999
"	W. Dean "	"	35·30	37·06	48·94	30·79	36·11	34·13	27·48	44·67	[illegible]	[illegible]	36·962	− [illegible]
III.	Hemelhempstead	Herts	26·43	27·75	34·22	21·20	27·44	22·76	16·96	30·25	[illegible]	[illegible]	[illegible]	− [illegible]
"	Berkhempstead	"	28·05	29·45	36·24	24·10	29·50	26·75	19·82	31·70	[illegible]	[illegible]	[illegible]	− [illegible]
"	Oxford (22 ft.)	Oxford	22·24	23·35	26·88	20·29	23·39	18·25	14·85	23·90	[illegible]	[illegible]	[illegible]	− [illegible]
"	Althorpe	Northampton	20·34	21·36	27·34	19·40	24·21	16·97	17·21	25·50	28·59	24·38	22·852	+ [illegible]
	Cardington (8-in. gauge)	Bedford	21·60	22·68	25·96	19·73	22·17	18·71	17·41	27·25	[illegible]	[illegible]	[illegible]	+ [illegible]
IV.	Epping	Essex	23·18	24·34	37·03	20·42	25·86	19·25	14·80	26·94	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Witham	"	20·55	21·58	26·08	18·83	21·78	17·33	15·40	24·99	[illegible]	[illegible]	[illegible]	− [illegible]
	Honingham (Norwich)	Norfolk	25·99	27·29	33·66	25·04	22·81	18·62	14·62	25·55	[illegible]	[illegible]	[illegible]	− [illegible]
	Burnham	"	26·26	28·20	34·65	24·78	26·71	22·96	17·68	29·13	[illegible]	[illegible]	[illegible]	− [illegible]
V.	Baverstock	Wilts	28·69	30·13	37·45	26·75	30·30	30·45	21·40	31·10	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Exeter Institution	Devon	26·91	28·26	36·08	25·80	29·58	31·44	22·62	35·47	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Broadhembury, Honiton	"	32·75	34·39	42·62	28·52	36·77	35·28	25·37	37·15	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Helston	Cornwall	36·22	38·03	42·96	37·62	38·43	35·96	28·56	44·74	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Truro		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+ [illegible]
VI.	Guernsey	Channel Islands	34·46	36·19	48·00	31·22	32·50	34·80	32·66	43·35	[illegible]	[illegible]	[illegible]	+ [illegible]
V.	Swanswick, Bath	Somerset	25·20	26·46	28·64	23·34	26·52	23·56	16·88	25·95	[illegible]	[illegible]	[illegible]	− [illegible]
VI.	Cirencester	Gloucester	29·60	31·08	36·94	27·39	32·46	27·95	24·68	35·82	[illegible]	[illegible]	[illegible]	+ [illegible]
	Burford	Shropshire	25·52	26·80	31·55	26·72	31·10	24·40	19·30	24·45	[illegible]	[illegible]	[illegible]	[illegible]
"	Haughton Hall, Shiffnal	"	24·02	25·22	31·23	23·80	25·70	21·21	17·23	23·25	[illegible]	[illegible]	[illegible]	− [illegible]
	Orleton	Worcester	28·82	30·26	36·89	29·81	34·31	27·67	21·79	29·88	[illegible]	[illegible]	[illegible]	+ [illegible]
VII.	Wigston	Leicester	26·39	27·71	31·47	23·20	26·13	21·77	17·60	26·80	[illegible]	[illegible]	[illegible]	− [illegible]
"	Boston	Lincoln	20·55	21·58	30·69	20·38	19·93	18·29	15·23	25·79	[illegible]	[illegible]	[illegible]	+ [illegible]
	Welbeck	Nottingham	23·29	24·45	30·54	24·16	22·77	19·55	22·60	24·51	[illegible]	[illegible]	[illegible]	+ [illegible]
	[illegible]	Derby	23·98	25·18	32·77	22·01	26·28	23·60	21·74	24·46	[illegible]	[illegible]	[illegible]	+ [illegible]
VIII.	The Folds, Bolton	Lancashire	44·01	46·21	57·66	44·91	53·43	53·75	42·74	37·51	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Belmont, "	"	51·19	53·75	59·80	55·70	61·90	66·00	48·20	42·60	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Howick, Preston	"	34·28	36·00	39·76	36·59	44·33	41·87	34·41	31·55	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Coniston	"	71·40	74·97	89·50	102·20	96·40	83·90	71·90	72·10	[illegible]	[illegible]	[illegible]	+ [illegible]
IX.	Redmires	Yorkshire	37·86	39·75	44·28	37·94	40·06	40·70	31·88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Holbeck W. W., Leeds	"	23·31	24·40	27·19	23·33	21·79	20·62	17·04	25·78	[illegible]	[illegible]	24·543	+ [illegible]
"	Eccup, " "	"	24·98	26·23	31·00	24·25	26·11	25·18	18·95	22·66	[illegible]	[illegible]	[illegible]	− [illegible]
	York	"	[illegible]	[illegible]	[illegible]	[illegible]	23·11	[illegible]	21·13	23·19	[illegible]	[illegible]	[illegible]	+ [illegible]
	[illegible]	"	35·55	37·33	41·78	41·79	43·77	44·28	32·60	35·38	[illegible]	[illegible]	[illegible]	+ [illegible]
X.	Bishopwearmouth	Durham	16·91	17·76	24·71	19·30	20·97	21·71	19·52	20·73	[illegible]	[illegible]	[illegible]	+ [illegible]
"	Seathwaite	Cumberland	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+ [illegible]

SCOTLAND.

Division	Station	County	Average, 1850–59	Average, 1850–59 +5 p.c.	1860.	1861	1862	1863.	1864.	1865.	1866.	1867	Average, 1860–67.	Difference from average of 50 years.
XII.	Mull of Galloway	Wigtown	22·52	23·65	29·23	26·84	25·44	26·87	34·07	27·41	30·48	26·71	[illegible]	+ [illegible]
"	Little Ross	Kirkcudbright	25·27	26·53	28·79	29·30	26·87	27·30	26·59	25·24	28·70	21·65	[illegible]	+ [illegible]
XIII.	Haddington	Haddington	24·35	25·57	27·30	25·90	29·80	23·00	28·10	27·50	24·80	27·00	[illegible]	+ [illegible]
"	Cobbinshaw	Edinburgh	35·65	37·43	30·90	37·80	42·20	36·80	36·50	29·70	41·90	38·60	[illegible]	[illegible]
"	Inveresk	"	24·72	25·96	31·97	28·51	32·89	29·10	30·02	27·78	28·98	31·11	[illegible]	+ [illegible]
XIV.	Bothwell Castle	Lanark	[illegible]	[illegible]	26·02	25·44	38·96	30·32	25·56	23·70	33·85	27·66	[illegible]	− [illegible]
"	Mansfield	Ayr	43·06	45·21	44·60	55·80	54·70	54·10	42·80	39·80	54·70	44·00	[illegible]	+ [illegible]
"	Brisbane	"	46·86	49·20	48·45	62·00	59·70	55·60	48·90	44·80	55·80	50·20	[illegible]	+ [illegible]
XV.	Arddarroch	Dumbarton	66·55	69·88	72·93	86·90	85·13	78·63	70·60	60·79	89·35	70·50	[illegible]	+ [illegible]
	Pladda	Bute	35·23	36·99	38·38	42·84	53·69	43·34	23·53	26·95	44·16	40·58	[illegible]	+ [illegible]
"	Mull of Cantire	Argyll	41·19	43·25	49·04	40·48	43·22	43·55	38·50	52·86	47·54	46·00	[illegible]	+ [illegible]
"	Rhinns of Islay	"	30·58	32·11	30·51	34·34	34·47	35·21	27·17	34·35	38·71	31·73	[illegible]	+ [illegible]
"	Castle Toward		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43·89	63·85	55·03	[illegible]	+ [illegible]
"	Lismore		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54·12	[illegible]	40·11	53·83	46·38	[illegible]	+ [illegible]
	Ardnamurchan		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37·45	[illegible]	+ [illegible]
	Tyree (Hynish)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76·70	78·72	62·56	[illegible]	+ [illegible]
XVI.	Isle of May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15·81	18·02	19·38	[illegible]	+ [illegible]
	Deanston	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33·75	49·72	44·15	[illegible]	+ [illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27·46	30·78	27·93	[illegible]	− [illegible]
	Dundee (Hill Head)	Forfar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33·96	34·06	35·51	[illegible]	+ [illegible]
	" (Craigton)	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33·42	33·84	33·86	[illegible]	+ [illegible]
"	Arbroath	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27·88	25·98	28·88	[illegible]	+ [illegible]
XVII.	Aberdeen (Girdleness)	Kincardine	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19·62	22·50	23·90	[illegible]	+ [illegible]
"	Strathdon (Castle Newe)	Aberdeen	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33·82	33·32	[illegible]	[illegible]
"	Peterhead (Buchanness)	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+ [illegible]
XVIII.	Cromarty	Cromarty	23·67	24·85	35·86	41·13	20·36	26·63	23·32	19·51	25·74	21·43	[illegible]	+ [illegible]
"	[illegible]	Inverness	[illegible]	[illegible]	28·44	33·66	[illegible]	26·73	36·77	35·44	[illegible]	20·81	[illegible]	− [illegible]
	Harris (Island of Glass)	"	31·92	33·52	25·04	33·63	35·14	23·90	17·51	17·93	30·10	36·26	[illegible]	− [illegible]
XIX.	Cape Wrath	Sutherland	36·94	38·79	35·08	40·26	40·26	50·95	38·19	32·80	38·85	28·04	[illegible]	− [illegible]
"	Wick (Noss head)	Caithness	25·57	26·85	27·23	26·81	21·04	23·99	27·23	15·09	26·28	24·68	[illegible]	− [illegible]
"	Dunnethead	"	22·09	23·19	25·62	30·14	25·11	24·42	28·45	21·85	29·72	33·30	[illegible]	+ [illegible]
	Pentland Skerries	"	24·12	25·33	26·37	32·51	29·23	27·40	31·94	26·05	29·33	26·62	[illegible]	+ [illegible]
	Sandwick	Orkney	36·14	37·95	37·96	41·18	34·38	39·72	33·28	34·21	41·55	39·39	[illegible]	[illegible]
	Start Point	"	23·77	24·96	23·01	29·30	25·54	25·29	23·92	18·83	25·26	36·6	[illegible]	+ [illegible]
	Sumburghead	Shetland	25·22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

IRELAND.

Division	Station	County	Average, 1850–59	Average, 1850–59 +5 p.c.	1860.	1861	1862	1863.	1864.	1865.	1866.	1867	Average, 1860–67.	Difference from average of 50 years.
XX.	[illegible]	Waterford	39·49	41·47	46·71	49·31	50·10	41·74	40·27	47·25	41·24	41·14	44·720	+ [illegible]
	[illegible]	Clare	38·33	40·25	48·76	51·84	47·37	50·53	35·64	46·04	51·78	46·87	47·354	+ [illegible]
XXI.	Tullamore	King's Co.	24·37	25·59	29·39	29·53	31·31	27·42	23·89	26·92	26·36	27·45	27·784	+ 2·194
"	Black Rock	Dublin	21·78	22·87	26·70	24·67	24·98	25·07	25·73	29·80	27·54	26·11	26·075	+ 3·205
XXIII.	Armagh	Armagh	33·92	35·62	36·35	42·04	41·05	39·00	32·14	36·01	37·90	36·73	37·778	+ [illegible]
"	Belfast (Linen Hall)	Antrim	30·13	31·63	39·84	37·41	41·18	38·55	35·93	35·78	39·54	30·77	37·375	+ [illegible]

[illegible] 1860 [illegible] 186[illegible] to Mean of [illegible] years

ENGLAND AND WALES

Divn.	Station	County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mean
II	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	Kent	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	Sussex	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	West Dean		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
III	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Althorp	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
IV	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	Norfolk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V	[illegible]	Wilts	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	Devon	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Truro	Cornwall	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XI	Guernsey	Channel Isles	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V	[illegible] Park		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VI	Cirencester	Gloucester	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Haughton Hall Shifnal	Shropshire	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	Worcester	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VII	Wigston	Leicester	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Boston	Lincoln	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Welbeck	Nottingham	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Derby	Derby	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VIII	[illegible] Bolton	Lancashire	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible] Preston		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
IX	[illegible]	Yorkshire	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible] Leeds	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	York		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
X	[illegible]	Durham	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Seathwaite	Cumberland	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Average, England		122	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	113	[illegible]	[illegible]

SCOTLAND

Divn.	Station	County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mean
XII	Mull of Galloway	Wigtown	[illegible]	114	[illegible]	114	[illegible]	[illegible]	[illegible]	113	[illegible]
	[illegible]	Kirkcudbright	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XIII	[illegible]	Haddington	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	Edinburgh	[illegible]	[illegible]	113	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XIV	[illegible] Castle	Lanark	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	116	[illegible]	[illegible]
"	[illegible]	Ayr	99	[illegible]	121	[illegible]	[illegible]	[illegible]	121	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	121	[illegible]	[illegible]	[illegible]	113	[illegible]	[illegible]
XV	[illegible]	Dumbarton	[illegible]	124	122	112	[illegible]	[illegible]	128	[illegible]	[illegible]
"	[illegible]	Bute	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Mull of Cantyre	Argyll	114	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible] Islay	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Castle Toward		[illegible]	[illegible]	124	114	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	115	113
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	114	[illegible]	126	[illegible]	115
	[illegible]		114	115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XVI	Isle of May	Fife	136	[illegible]	[illegible]	[illegible]	142	[illegible]	113	121	128
"	[illegible]	Perth	91	[illegible]	[illegible]	[illegible]	[illegible]	82	121	[illegible]	[illegible]
	[illegible]		[illegible]	113	112	91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Dundee [illegible]	Forfar	115	[illegible]	114	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	"	112	[illegible]	114	[illegible]	122	[illegible]	[illegible]	[illegible]	[illegible]
"	Arbroath		116	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	111
XVII	Aberdeen [illegible]	Kincardine	[illegible]	[illegible]	123	[illegible]	[illegible]	95	[illegible]	116	[illegible]
	[illegible] Castle New[illegible]	Aberdeen	[illegible]	[illegible]	85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	99
"	[illegible]		[illegible]	[illegible]	91	[illegible]	[illegible]	84	[illegible]	[illegible]	[illegible]
	Kinnaird Head		[illegible]	[illegible]	[illegible]	[illegible]	115	[illegible]	[illegible]	[illegible]	[illegible]
XVIII	Cromarty	Cromarty	144	[illegible]	82	[illegible]	94	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	Inverness	[illegible]	93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible] Island of Glass	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XIX	Cape Wrath		[illegible]	[illegible]	[illegible]	131	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Wick [illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	92	[illegible]
"	Dunnet Head	Caithness	[illegible]	[illegible]	[illegible]	[illegible]	122	94	128	143	118
"	Pentland Skerries	"	[illegible]	[illegible]	115	[illegible]	[illegible]	[illegible]	110	[illegible]	113
	[illegible]	Orkney	[illegible]	[illegible]	91	[illegible]	88	[illegible]	[illegible]	[illegible]	[illegible]
"	Start Point		92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Sumburgh Head	Shetland	98	[illegible]	[illegible]	97	[illegible]	[illegible]	91	[illegible]	96
	Average, Scotland		[illegible]	113	111	[illegible]	[illegible]	[illegible]	115	[illegible]	[illegible]

IRELAND.

Divn.	Station	County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mean
XX	Portland	Waterford	113	119	121	[illegible]	[illegible]	114	[illegible]	[illegible]	[illegible]
"	[illegible]	Clare	121	129	118	126	[illegible]	114	[illegible]	110	[illegible]
XXI	[illegible]	[illegible]	115	[illegible]	122	[illegible]	93	[illegible]	[illegible]	[illegible]	[illegible]
	Black Rock	Dublin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	114	114
XXIII	Armagh	Armagh	[illegible]	115	115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Belfast [illegible]	Antrim	126	118	[illegible]	122	[illegible]	113	[illegible]	116	[illegible]
	Average, Ireland		116	118	[illegible]	111	96	113	114	[illegible]	112

ON [illegible]

If, for the sake of [illegible]
get averages more [illegible]
tops:—

Seawf[illegible]
Great[illegible]
Esk [illegible]

In the mountain [illegible]

Sprin[illegible]
Styeh[illegible]
The S[illegible]

And at stations [illegible]

(a) [illegible]
Wast[illegible]
Mose[illegible]
Brant[illegible]

(b) [illegible]
Seath[illegible]
Stone[illegible]
Large[illegible]

Evidently the qu[illegible] Seawfell is at a [illegible] quantity dimini[illegible] diminution is not [illegible] rapid on the west, [illegible] the average of the [illegible] bable general ratio [illegible] the quantity is redu[illegible] in 1061 feet of desce[illegible]

Draw in a diagram [illegible] tervals. L M=1061 [illegible] $h=67\cdot3$, $m=132\cdot0$ [illegible] tities of rain receiv[illegible] the quantity of rain [illegible] where about the ele[illegible] represented by a cu[illegible] elevation would be [illegible] ence (d) which is a [illegible] elevation from that [illegible]

* Mr Fl[illegible]

If, for the sake of computation, we bring in some other near stations, to get averages more free from local excess or defect, we find on the mountain tops:—

	feet.	inches.
Scawfell	3200	64·0
Greatend	2982	66·0
Esk Hause	2550	72·0
Mean	2911	67·3

In the mountain passes:—

	feet.	inches.
Sprinkling Tarn	1985	121
Styehead Tarn	1472	110
The Stye	1077	165
Mean	1511	132

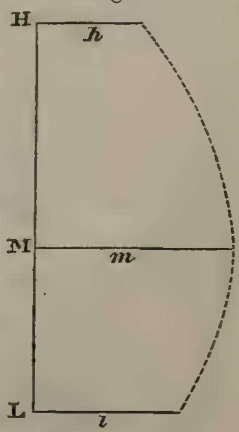
And at stations at the foot of the mountain:—

(a) On the West.	feet.	inches.
Wastdale Head	247	88
Mosedale	624	80
Brant Rigg	695	78
Mean	522	83·3

(b) On the East.	feet.	inches.
Seathwaite	422	134
Stonethwaite	330	107
Langdale	380	111
Mean	377	117·3
Mean of a and b=	450	100·3

Evidently the quantity of rain received on the surface of the ground near Scawfell is at a maximum at about half the height of the mountain, the quantity diminishing from this level both upwards and downwards. The diminution is not at the same rate on the two sides of the range, being very rapid on the west, sensibly slower on the east. Taking the average of these results as giving the most probable general ratio, we find in 1400 feet of ascent the quantity is reduced from 132·0 to 67·3 inches, and in 1061 feet of descent from 132·0 to 100·3*.

Fig. 1.



Draw in a diagram (fig. 1) L M H, vertical; with intervals, L M=1061, M H=1400. Set off ordinates; h=67·3, m=132·0, l=100·3 representing the quantities of rain received at the several elevations. As the quantity of rain passes through a maximum somewhere about the elevation M, it may be conceived to be represented by a curve, in which the quantity at any elevation would be less than the maximum, by a difference (d) which is a function of the difference(D) of this elevation from that of the maximum.

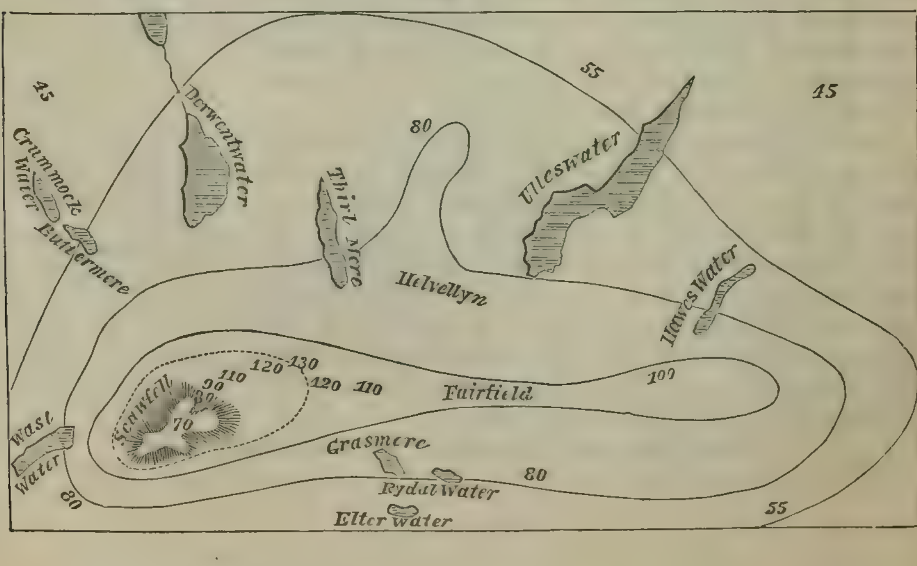
* Mr. Fletcher admits 134 inches as the most probable average.

The curve may be assumed to be parabolic, in which case $\frac{D^2}{d}$ is constant, and the vertex of the parabola is found at 1463 feet, and the average of rain at that elevation is 132·1. The average quantity of rain at two stations on opposite sides of the mountains having the same elevation, $= 132{\cdot}1 - r\,D^2$, r being a coefficient determined from the observations. On the eastern side of the mountain, r (very irregular) is found $= {\cdot}0000126$, but on the western side ·000055.

If we now turn our attention to the Skiddaw group of mountains, the results are very different, the quantities of rain registered there being reduced to about half, viz. 55 inches on Skiddaw, at 1677 feet elevation; 57 inches on Derwent Island, 240 feet; and 59 inches at Keswick, 270 feet. Nor is the case very different about Helvellyn, where Birkside, 1800 feet, receives 81 inches, and Wythburn, 574 feet, 90 inches. Similar effects about Kirkstone Pass, 1500 feet, 82 inches; Matterdale, 1400 feet, 80 inches; and Patterdale, 500 feet, 75 inches. In all these cases, the interior Lake mountains, though of nearly the same height as Scawfell, exercise no such remarkable effect on the quantity and distribution of rain; the reason being that they do not receive the first brunt of the moist south-west wind.

On the other hand, groups of mountains removed from Scawfell, which front the south-west, exhibit similar if not equal effects. Thus, to the influence of the group of mountains about the Old Man may be ascribed the large deposit of rain about Esthwaite Lake (80), Coniston Water-head (100), and Langdale (111); and the long range of the Fells, north of Kendal, is probably the cause of the heavy rain in Mardale (108 inches) and West Sleddale (113 inches). Another centre of rain-dispersion may be indicated in Hougill Fells and Wharnside, on the eastern side of the Lake district; but no sufficient observations are on record for these districts. The axis of most rain may be drawn along the main summit of drainage from Scawfell by Fairfield toward Hougill Fell; rudely parallel to it, and turning round it on the east and on the west, are curves of equal rain—80, 55, and 45 inches, the latter moderate quantity being succeeded on the eastward by 40, 30, 25, and 20 inches, the minimum being on the Yorkshire coast, where the far-ravelled rain-clouds have lost much of their valuable burden. (See Map, fig. 2.)

Fig. 2.



Report of Synthetical Researches on Organic Acids. By ALFRED R. CATTON, *M.A., F.R.S.E., Fellow of St. John's College, Cambridge.*

1. AT the Dundee Meeting of the British Association in September 1867, I was requested to continue my researches on the action of carbonic acid and sodium on alcohol, and a grant was placed at my disposal for the purpose.

This Report is presented to the Association in compliance with the law which requires that, when a grant of money has been made at one Meeting, a Report of the progress of the research shall be presented at the next Meeting.

2. One principal object of my labours during the past year has been to convert as large a proportion as possible of the sodium used in the reaction into organic salts, and I am now able to report that, instead of obtaining from 100 grammes of sodium only 7 grammes of sodium-salts of acids formed synthetically, I have succeeded in obtaining 175 grammes.

To give an account of the conditions necessary to this result, and of the experiments by which it is established, is the object of this Report.

3. My previous experiments had shown that, in order to obtain the largest quantity of synthetically formed salts, it was necessary,—

(1) That the action of the sodium on the alcohol be modified as much as possible, and with this object the sodium was added gradually and in small pieces.

(2) That the temperature of the alcohol be kept as low as possible, by surrounding the Woulfe's bottle containing it with a mixture of ice and salt.

The manner in which this last condition influenced the reaction was no doubt by increasing the amount of carbonic acid which the alcohol dissolved. It tended also to modify the action of the sodium.

Now it occurred to me that the most effectual way to modify the action of the sodium, was to use sodium-amalgam containing such a small percentage of sodium that it might act almost imperceptibly on absolute alcohol. I therefore determined to use sodium-amalgam containing about 2 per cent. of sodium.

4. The apparatus used was very simple. Carbonic acid, from a gasogene, was washed and dried. The gas was then passed through a refrigerator, which consisted of a large wooden box lined inside with zinc, and containing a long spiral leaden tube. Ice was put into the box, and surrounded the tube, and thus the gas, on emerging from the refrigerator, was at 0° C. The refrigerator served also as a storehouse for the ice, and in it 50 lbs. of ice could be kept for several days without being all melted. The gas was then passed through a series of Woulfe's bottles, surrounded with ice and salt, contained in a wooden trough lined with zinc, and covered with a wooden lid.

5. Absolute alcohol was obtained from Messrs. T. & H. Smith, of Edinburgh, of sp. gr. ·7957 at 60° F. It was distilled from sodium, and its sp. gr. was then ·7940 at 60° F. Sodium-amalgam was prepared by heating mercury, and then adding sufficient sodium to make an amalgam of about 2 per cent. The amalgam was subsequently fused to render it of uniform composition, the fluid part poured on a slab, and, when cool, placed in bottles containing dry carbonic acid. The amalgam was uniformly crystallized in slender needles, which had not tarnished in the slightest degree when used.

6. In order to determine the amount of sodium used in the reaction, it is necessary to know accurately the percentage of the sodium in the amalgam. Two determinations of this percentage were therefore made.

I. 10·4695 grms. of the amalgam were left in contact with standard sulphuric acid, and, when gas ceased to be evolved, excess of acid was titrated with standard caustic soda.

It was thus found that

10·4695 grms. contained ·1794 grm. sodium. The amalgam therefore contained 1·714 per cent. sodium.

II. 8·015 grm. amalgam were boiled in a flask with water till there was no perceptible evolution of gas. The caustic soda produced was titrated with standard sulphuric acid.

It was thus found that

8·015 grms. contained ·1403 grm. sodium. The amalgam therefore contained 1·750 per cent. sodium. The mean of these determinations gives 1·732 as the percentage of sodium in the amalgam.

7. One hundred cub. centims. absolute alcohol were added to each of eight carefully dried Woulfe's bottles. Carbonic acid was passed for an hour, in order thoroughly to saturate the alcohol, and then sodium-amalgam added to each bottle by means of a glass-stoppered neck. For reasons which will be subsequently understood, the last four bottles were detached after about twelve hours, and the reaction went on in them without any more carbonic acid being passed.

The gas was passed through the other four bottles for three days, the temperature of the alcohol, for nearly the whole time, being several degrees below 0° C.

8. Before describing the method of examining the product of the reaction, a few words of explanation are necessary. If sodium is dissolved in absolute alcohol, sodium-alcohol is formed and hydrogen given off. If dry carbonic acid be passed into the sodium-alcohol, the sole product is ethylcarbonate of sodium, to which has been assigned the formula $CO_2 \left.\begin{matrix} Na \\ C_2H_5 \end{matrix}\right\} O$. This compound is decomposed by acids into alcohol and the sodium-salt of the acid; by oxalic acid, for instance, into alcohol and oxalate of sodium.

Now if a known weight of sodium be added to absolute alcohol, and whilst the sodium is dissolving a current of dry carbonic acid be passed, it is found that the number of cub. centims. of standard acid required to neutralize the ethylcarbonate is less than is equivalent to the sodium used. If W be the weight of sodium used, and x the number of cub. centims. of standard oxalic acid, containing 63 grms. crystallized oxalic acid in the litre, required to neutralize the ethylcarbonate, $x \times \cdot 023$ is less than W, and $W - x \times \cdot 023$ is the amount of sodium incapable of neutralizing standard acid, and which, in fact, exists as sodium in salts of acids formed synthetically.

9. If *sodium amalgam* and carbonic acid act upon alcohol, in order to determine the sodium used in the reaction, we must know,—

i. The amount of sodium in the sodium-amalgam. This is determined by calculation from the weight of amalgam used and the percentage of sodium it contains.

ii. The amount of sodium left in the amalgam after stopping the reaction. This is determined by leaving the residue of amalgam in contact with standard sulphuric acid, and determining excess of acid by standard caustic soda.

i. minus ii. gives (w) the sodium used in the reaction; and if, as before, x

be the number of cub. centims. standard oxalic acid required to neutralize the ethylcarbonate, $w-x\times\cdot023$ is the sodium converted into salts of organic acids. It is assumed in the above that an amalgam can be made of uniform composition, or nearly so, as, in fact, my experiments have shown.

Experience shows that the operations, as above described, can be carried out so as to give results of great nicety.

Oxalic acid is used in these determinations on account of the sparing solubility of oxalate of sodium in water and alcohol, which enables us to separate it at once from the sodium-salts formed synthetically.

10. We now proceed to state the results of the examination of the contents of the several bottles. The products of the reaction in the first four bottles were added together, the amalgam in each bottle being rapidly washed with water, so that as little as possible of the sodium it contained might appear as caustic soda in the washings.

430·5 cub. centims. oxalic acid were required to render the solution neutral, as determined by very delicate neutral test-paper. Therefore Na as ethylcarbonate$=9\cdot90$ grammes.

740 cub. centims. standard sulphuric acid were required to neutralize sodium which remained in amalgam, which was therefore 17·02 grms.

11. The amount of sodium originally contained in the amalgam was determined from the weight of mercury left after extracting the sodium from the amalgam.

If (Hg+Na) denote the weight of sodium-amalgam used, and (Na) the sodium contained therein, we have

$$(\mathrm{Hg}+\mathrm{Na}):(\mathrm{Na})::100:1\cdot732;$$

$$\therefore (\mathrm{Hg}):(\mathrm{Na})::98\cdot268:1\cdot732,$$

$$\text{or } (\mathrm{Na})=\frac{(\mathrm{Hg})\times1\cdot732}{98\cdot268}.$$

(Hg), the weight of mercury, was found to be 1954·84 grms.;

$$\therefore (\mathrm{Na})=\frac{1954\cdot84\times1\cdot732}{98\cdot268}=34\cdot45 \text{ grms.}$$

Hence 34·45 grms. sodium were contained in amalgam used. From this, subtracting 17·02, the sodium left in amalgam, we get 17·43 grms. as the amount of sodium used in the reaction.

Of these 17·43 grms. sodium 9·90 were converted into ethylcarbonate.

Therefore the remaining 7·53 grms. existed as sodium in salts of acids formed synthetically.

Hence 56·22 = percentage of sodium converted into ethylcarbonate, and
43·78 = „ „ „ salts of organic acids.

12. We now proceed to find the total weight of salts formed synthetically.

For this purpose advantage is taken of the sparing solubility of oxalate of sodium in alcohol.

Three solubility determinations at the ordinary temperature gave the following results:—

1 part oxal. of Na	dissolves in	143	pts. by weight of	alcohol of	20	per cent.
„	„	1077	„	„	40	„
„	„	6250	„	„	60	„

The solution containing the products of the reaction, after neutralization

with oxalic acid, was evaporated to dryness, and the residue treated with alcohol of 20 per cent., which dissolves the salts formed synthetically, and leaves pure oxalate of sodium, as the following analysis shows:—

·522 grm. of the residue gave ·5475 grm. Na_2SO_4, or ·1774 Na.
The salt therefore contained 34·11 per cent. Na.
Oxalate of Na contains 34·33 per cent. Na.

The solution in alcohol of 20 per cent. was evaporated to dryness, and heated till it ceased to lose weight in a weighed crucible, a little absolute alcohol being added to facilitate the drying of the deliquescent residue.

Weight of organic salts=22·32 grms.

Now 23 grms. sodium correspond to 112 sodium ethylcarbonate. Hence the weight of ethylcarbonate corresponding to 9·90 grms. sodium is 48·21 grms.

Hence as from 17·43 grms. sodium are obtained

22·32 grms. organic salts, and
48·21 grms. sodium ethylcarbonate,

from 100 grms. sodium would be obtained

128·06 grms. organic salts, and
276·59 grms. sodium ethylcarbonate.

13. If, now, the organic salts be decomposed by a solution of oxalic acid in alcohol of 60 per cent., containing just sufficient oxalic acid to convert 7·53 grms. sodium into acid oxalate, the sodium is converted into acid oxalate, and the acids remain in solution. On distilling the acid solution, alcohol goes over accompanied by the volatile acids. If water be added to the retort till the liquid which distils over is very faintly acid, the distillate contains the whole of the volatile acids, and the fixed acids remain in the retort.

The acid distillate required for neutralization 148 cub. centims. standard caustic soda, which are equivalent to 3·40 grms. Na; therefore, 3·40 grm. Na existed in salts of volatile acids. Now 7·53 was the whole quantity of sodium in organic salts.

Hence, of the sodium in organic salts,

45·15 per cent. existed in salts of volatile acids, and
54·85 „ „ „ fixed acids.

14. The solution of sodium-salts of volatile acids was evaporated to dryness, and dried till it ceased to lose weight.

Weight of residue=10·37 grms.;

and as the total weight of organic salts was 22·32 grms.,

11·95 grms. were salts of fixed acids.

Hence, of the total organic salts,

46·46 per cent. were sodium-salts of volatile acids, and
53·54 „ „ „ fixed acids.

15. The results of the examination of the remaining bottles will not be given in detail. They are collected in the following Table, the first vertical column containing the results of the examination of the first four bottles, and the other columns those of the last four bottles:—

	I.	1.	2.	3.	4.
Na as ethylcarbonate........	56·22	74·46	79·43	69·38	76·47
Na in salts of organic acids ..	43·78	25·54	20·57	30·62	23·53
Na in salts of volatile acids ..	45·15	35·38	41·49	48·30	79·81
Na in salts of fixed acids	54·85	64·62	58·51	51·70	20·19

16. Now carbonic acid was passed through the last four bottles for several hours and then stopped, the sodium-amalgam continuing to act on the contents of each bottle for about two months till it contained no more sodium.

From the last four columns of the Table we see that thus a much larger proportion of sodium is converted into ethylcarbonate and a much smaller proportion into organic salts. Whence we conclude that the proportion of sodium converted into organic salts is much increased by keeping a current of carbonic acid constantly passing through the alcohol.

17. It will be observed that the proportion of the fixed to the volatile acids diminishes from the second to the last column. This result is difficult to explain; but other observations tend to throw light on the conditions which determine the proportion of the fixed to the volatile acids in the ultimate product.

18. The results of the foregoing experiments indicated the possibility of converting a still larger proportion of sodium into organic salts. I therefore determined to repeat the reaction, taking advantage of the experience gained both during the reaction and the subsequent analytical operations.

19. Two determinations were made of the percentage of sodium in the amalgam used in the reaction to be now described, and to render them as accurate as possible much larger quantities of amalgam were analyzed. They were made as before, by leaving the amalgam in contact with standard sulphuric acid and determining excess of acid by standard caustic soda.

I. 286·97 grms. amalgam required for neutralization 202·9 cub. centims. standard acid, which are equivalent to 4·668 grms. Na.

Therefore 100 grms. contained 1·626 grm. Na.

II. 135·05 grms. amalgam required for neutralization 96·1 cub. centims. standard acid, which are equivalent to 2·21 grms. Na.

Therefore 100 grms. contained 1·636 grm. Na.

The mean of these two closely concordant determinations gives 1·631 as the percentage of sodium in the amalgam.

20. 1420·8 grms. of this amalgam were put into a large Woulfe's bottle, and 500 cub. centims. absolute alcohol added.

Carbonic acid was kept constantly passing through the alcohol for three days, the apparatus being the same as before.

21. To the product of the reaction in the Woulfe's bottle 250 cub. centims. standard oxalic acid were added, and a rapid current of air blown through the liquid, which was then found to be acid, and required for neutralization 2 cub. centims. standard caustic soda. Hence 248 cub. centims. standard acid were equivalent to sodium as ethylcarbonate, which was therefore 5·70 grms.

The contents of the bottle were then transferred to a beaker and the amalgam washed with water. Some of the sodium left in the amalgam thus

appeared as caustic soda in the washings; 34 cub. centims. standard oxalic acid were required to neutralize this caustic soda, which must therefore be added to the cub. centims. standard acid required to neutralize sodium left in the amalgam. For the latter purpose 391·6 cub. centims. were required. Therefore 391·6+34, or 425·6 cub. centims. are equivalent to sodium which remained in amalgam, which was therefore 9·79 grms.

22. Now the weight of amalgam used was 1420·8 grms., and it contained 1·631 per cent. sodium.

Hence we have

Whole Na in amalgam	=	23·18 grms.
Na left in amalgam	=	9·79 „
∴ Sodium used in reaction	=	13·39 grms., and
Na as ethylcarbonate	=	5·70 „
∴ Na in organic salts	=	7·69 grms.

Hence, of the sodium used in reaction,

42·57 = percentage converted into ethylcarbonate, and
57·43 = „ „ „ organic salts.

23. In the manner before described, the *weight* of organic salts was found to be 23·34 grms.

Now 5·7 grms. sodium are equivalent to 27·76 sodium ethylcarbonate. Therefore, from 13·39 grms. sodium were obtained

23·34 grms. organic salts, and
27·76 grms. sodium ethylcarbonate.

Hence from 100 grms. sodium would be obtained

174·3 grms. organic salts, and
207·3 grms. sodium ethylcarbonate;

or, in round numbers, 175 grms. organic salts are obtained from 100 grms. sodium.

24. As before, the acids were liberated from 19·59 grms. of the organic salts, the remaining 3·75 grms. being used for other purposes. The volatile acids, after redistillation, required for neutralization 55·9 cub. centims. standard caustic soda, or 1·285 grm. Na.

Now, since 23·34 grms. of the organic salts contained 7·69 grms. Na, 19·59 grms. contained 6·476 grms. sodium, of which, as we have found, 1·285 grm. were in salts of volatile acids.

Therefore

19·85 = percentage of sodium in salts of volatile acids, and
80·15 = „ „ „ fixed acids.

25. The weight of sodium-salts of volatile acids was found to be 4·08 grms.

Hence, as the weight of the mixture of salts of fixed and volatile acids was 19·59 grms.,

Weight of sodium-salts of fixed acids = 15·51 grms.

Therefore, of the total organic salts,

20·82 per cent. were salts of volatile acids, and
79·18 „ „ fixed acids.

26. Hence we have the following results:—

Na as ethylcarbonate	42·57 per cent.
Na in organic salts	57·43 „
Na in salts of volatile acids	19·85 „
Na in salts of fixed acids	80·15 „

The results of this experiment show that, by keeping a current of carbonic acid constantly passing through the alcohol, the proportion of the fixed to the volatile acids is greatly increased, as well as the percentage of sodium converted into organic salts. But *how* a constant current of carbonic acid acts in this way, is a question to which at present I can give merely a conjectural answer.

27. In the first experiment 22·32 grms. organic salts were obtained, and it was found that 19·87 grms. were soluble in alcohol of 80 per cent., and therefore only 2·45 grms. insoluble therein. The mean of several determinations showed that a uniform mixture of the salts soluble in 80 per cent. alcohol required for solution 30 times its weight of alcohol of this percentage.

28. In the last experiment the total weight of organic salts was 23·34 grms., and we found they contained 7·69 grms. Na.

Hence the mean percentage of sodium in the salts was 32·95. This result is confirmed by the following analysis:—

The dried sodium salts were mixed in a mortar, so as to be as nearly as possible of uniform composition,

1·2714 grm. of the mixture gave 1·2977 grm. $Na_2 SO_4$, or ·4204 Na.

The salts therefore contained 33·06 per cent. Na.

Numerous other analyses agreed with these results.

29. Now it is remarkable that the percentage of sodium in the organic salts is nearly the same as in formiate of sodium, which contains 33·82 per cent. sodium; yet of the organic salts in the last experiment only about one-fourth were salts of volatile acids, and therefore not more than one-fourth could be formiate of sodium.

Now oxalate of sodium, which contains 34·33 per cent. sodium, is the only salt the percentage of sodium in which is nearly the same as in formiate of sodium; so that, at first sight, it seems difficult to understand how a mixture of sodium salts of fixed and volatile acids can contain 33·06 per cent. sodium. The following experiment shows how this is possible.

30. A determination was made of the sodium in a uniform mixture of that portion of the organic salts which dissolved in 80 per cent. alcohol.

·2168 grm. gave ·2253 grm. $Na_2 SO_4$, or ·0729 grm. Na.

The mean percentage of sodium in the salts was therefore 33·66.

Hence, by calculation, 1·3932 grm. of the same salts contains ·4689 grm. sodium. 2·562 grms. crystallized oxalic acid, which are just sufficient to convert ·4689 grm. sodium into acid oxalate, were dissolved in alcohol and added to the solution of the above 1·3932 grm. in alcohol of 80 per cent. The solution was filtered and the precipitated acid oxalate of sodium washed with alcohol of 80 per cent. The filtrate required for neutralization 13·3 cub. centims. standard caustic soda, or ·3059 grm. Na, which is less than the sodium originally contained in the salts by ·163 grm. On evaporating the neutralized solution to dryness, the weight of the residue was found to be 1·2185 grm., which is less than the original weight of the salts by ·1747 grm., and this agrees very nearly with ·163 grm., the loss in sodium. The loss in weight of the salts was therefore a loss of sodium.

Hence we see that when the acids are liberated from the sodium-salts, as originally produced, they do not, when neutralized with caustic soda, take up the original quantity of sodium. The acids, therefore, were originally combined with more than a normal quantity of sodium; that is, not only was the basic hydrogen replaced by sodium, but also some of the non-basic or typical hydrogen.

31. To illustrate this, let us take the case of malic acid, $C_4 H_6 O_5$. If both the basic and typical hydrogen be replaced by sodium, we get a salt, $C_4 H_3 Na_3 O_5$, which contains 34·5 per cent. sodium. If the sodium in this compound were removed by oxalic acid, and the acid again neutralized, we should get the normal salt, $C_4 H_4 Na_2 O_5$, which only contains 25·84 per cent. Na. The compound $C_4 H_3 Na_3 O_5$ loses, it will be observed, one-third of its sodium when converted into the normal salt, $C_4 H_4 Na_2 O_5$.

Again, $C_2 H_2 Na_2 O_3$, disodium glycollate, contains 38·33 per cent. Na. If converted into $C_2 H_3 Na O_3$, it would lose one-half of its sodium, and then contain only 23·47 per cent. sodium.

As another example, $C_4 H_3 Na_3 O_6$, trisodium racemate, contains 31·94 per cent. Na, but the normal salt, $C_4 H_4 Na_2 O_6$, only contains 23·71 per cent. Na.

32. Now we found that the liberated acids required for neutralization ·3059 grm. Na, and the residue on evaporation was 1·2185 grm. Hence the residue contained 25·1 per cent. Na. This residue is, moreover, nearly insoluble in alcohol of 80 per cent. Hence, by liberating the acids from the sodium-salts, soluble in 80 per cent. alcohol, and again neutralizing, they are converted into salts insoluble in 80 per cent. alcohol, and the percentage of sodium is reduced from 33·66 to 25·1.

33. In the above experiment, the original quantity of sodium in the salts was ·4689, and the loss of sodium, as before stated, was ·163 grm.

$$\text{Now, } \frac{\cdot 4689}{\cdot 163} = 2{\cdot}88, \text{ which is nearly 3.}$$

The salts thus lose nearly *one-third* of their sodium. It does not follow from this, however, that the acids are principally dibasic and triatomic acids; for I have found the product of the reaction to be a very complex mixture, and therefore the *mean* loss of more than one-third of the sodium might result in a large number of ways from mixtures of sodium-salts of acids having a greater atomicity than basicity.

34. An aqueous solution of the salts soluble in 80 per cent. alcohol acquires, on evaporation, an alkaline reaction, owing to the formation of caustic soda, and the residue is not entirely soluble in 80 per cent. alcohol. Probably the whole of the synthetically formed salts are originally soluble in 80 per cent. alcohol, but, as might be expected from their containing more than a normal quantity of sodium, are partially decomposed by evaporation into caustic soda and salts insoluble in 80 per cent. alcohol, or into oxalate of sodium and the same salts by the addition of more oxalic acid than is sufficient to decompose the ethylcarbonate.

35. In previous Reports to the Association, I showed that formic acid is one of the volatile acids. It is not, however, the only one, as the following results prove.

Part of the volatile acids distilled over with the alcohol at 200° F. The distillate required for neutralization 8·85 cub. centims. standard caustic soda or ·2035 grm. Na. The residue, on evaporation, was ·61 grm., which therefore contained 33·36 per cent. Na. This result is confirmed by the following analysis: ·1614 grm. of the residue gave ·166 grm. $Na_2 SO_4$, or ·0538 Na. The residue therefore contained 33·32 per cent. Na, and was therefore nearly pure formiate, which contains 33·82 per cent. sodium.

The volatile acids which distilled above 200° F. required, for neutralization, 47·05 cub. centims. caustic soda, or 1·082 Na. The residue, on evaporation, was 3·466 grms., which therefore contained 31·22 per cent. Na, which is 2·6 per cent. less than in formiate.

Again, the volatile acids from the last four bottles required for neutralization 2·44 grms. Na, and the residue of sodium-salts was found to be 7·74 grms., which therefore contained 31·52 per cent. Na. This is 2·3 per cent. less than in formiate of sodium.

These results agree in showing that the volatile acids contain at least one acid of higher molecular weight than formic acid. I have recognized one such acid, and have succeeded in separating it from the formic acid.

36. The most general supposition which can be made with respect to the theory of the production of the fixed and volatile acids in these researches is, that they are due to the mutual action of carbonic acid, alcohol, and nascent hydrogen, evolved by the action of sodium-amalgam on absolute alcohol, as represented by the expression

$$x\,CO_2 + y\,H_2 + z\,C_2H_6O - w\,H_2O.$$

37. The results, however, of an elaborate examination of the fixed acids, into the details of which it is not my intention to enter here, taken in connexion with the conclusions drawn from the examination of the volatile acids, have shown that probably the whole of the volatile acids, and a considerable part of the fixed acids, are produced by the direct action of nascent hydrogen or carbonic acid, as represented by the equation

$$x\,CO_2 + y\,H_2 - w\,H_2O = C_x H_{2(x-w)} O_{2x-w}.$$

38. Before, then, we can determine the compounds (if any) for the production of which the presence of alcohol is essential, it is necessary to investigate thoroughly the fixed and volatile acids produced by the action of nascent hydrogen on carbonic acid when carbonic acid is passed through water containing sodium amalgam.

The replacement of the oxygen in carbonic acid by hydrogen in so simple a manner is undoubtedly a step in synthesis which assimilates, for the first time, our synthetical processes to those which we may suppose to take place in plants where the most complicated compounds are produced from carbonic acid and water.

39. The results of my researches during the past year may be briefly summarized as follows:—

(1) That if a current of dry carbonic acid be kept constantly passing through absolute alcohol which is in contact with sodium-amalgam containing about 2 per cent. of sodium, for every 100 grms. of sodium used in the reaction at least 175 grms. of sodium-salts of organic acids are formed synthetically, about 35 grms. of which are the sodium-salts of volatile acids, and the remaining 140 grms. are the sodium salts of fixed acids.

(2) That the volatile acids consist of formic acid and at least one other acid of higher molecular weight.

(3) That the fixed acids are principally acids having a greater atomicity than basicity, and they are originally produced as sodium-salts, in which both the basic and typical hydrogen of the acid are replaced by sodium.

(4) That probably the whole of the volatile acids, and a considerable part of the fixed acids, are produced by the direct action of nascent hydrogen on carbonic acid.

I cannot conclude this Report without thanking Dr. Maclagan, Professor of Medical Jurisprudence in the University of Edinburgh, for the great kindness and liberality with which he placed the resources of his laboratory at my disposal; but I am especially indebted to Dr. Arthur Gamgee for much valuable assistance.

Report on the best means of providing for a uniformity of Weights and Measures, with reference to the Interests of Science. By a Committee, consisting of Sir JOHN BOWRING, The Rt. Hon. C. B. ADDERLEY, *M.P.*, Mr. SAMUEL BROWN, Mr. W. EWART, *M.P.*, Dr. FARR, Mr. J. FRANK FELLOWS, Prof. FRANKLAND, Prof. HENNESSY, Mr. JAMES HEYWOOD, Sir ROBERT KANE, Prof. LEONE LEVI, Prof. W. A. MILLER, Prof. RANKINE, Mr. C. W. SIEMENS, Col. SYKES, *M.P.*, Prof. A. W. WILLIAMSON, Mr. JAMES YATES, Dr. GEORGE GLOVER, Mr. JOSEPH WHITWORTH, Mr. J. R. NAPIER, Mr. H. DIRCKS, Mr. J. N. V. BAZALGETTE, Mr. W. SMITH, Mr. W. FAIRBAIRN, Mr. JOHN ROBINSON :—Prof. LEONE LEVI, *Secretary*.

IT is now five years since, at the Meeting of the British Association held in Newcastle, a Committee was appointed to report on the best means of providing for a uniformity of weights and measures with reference to the interests of science, and since then their instructions have been enlarged to the effect that they should diffuse the knowledge of the relation amongst systems of Moneys, Weights, and Measures. Upon the first point regarding the uniformity of weights and measures, your Committee have already reported that the only mode of attaining such uniformity under present circumstances is by the universal adoption of the Metric System; and they are confirmed in that decision by the very general concurrence of opinion in favour of this system, the repeated decisions of the International Statistical Congress, the practical adoption of the Metric System by many civilized nations, the entire satisfaction it affords wherever it has been introduced, and, lastly, by the extended and growing public opinion in favour of the same in this country. Other natural units have been urged for consideration, but your Committee have decided on the Metre as the best unit, solely from practical considerations. They have seen the absolute necessity of a change in the Weights and Measures of the country, from the extreme complication of the tables, from the great diversities which exist throughout the country, and from the extreme difficulty of teaching the present method, or of retaining it when learnt. They are convinced that we cannot introduce even the decimal scale in the present system without producing considerable change, and they have concluded that if a change is to be made it is most desirable to adopt the Metric System, which is at once simple and complete, and is certain sooner or later to be in general use throughout the world. It should be remembered that the metre is no longer an abstract idea—a scientific conception. It is a definite length—the length of a concrete object, deposited at the Archives of Paris, and exactly copied in the standards within our own reach. The time is past for finding out the best natural unit, and we must be satisfied with what we have got; viz. a unit really universal from its wide diffusion among modern nations.

Your Committee are pleased to report that a Bill to establish Metric Weights and Measures has been introduced in the House of Commons by Mr. Ewart, and has met with a most satisfactory reception from both sides of the House. The President of the Board of Trade, Mr. Cave, in voting for the second reading of the same, said:—"There can be no doubt that the progress of opinion in this and other countries as to an international system of Weights and Measures as well as of coinage within the last few years has been remarkable. It may be dated from the Great Exhibition of 1851, and has received enor-

mous impulse from the increased facility of locomotion, and the growth of telegraphic as well as postal communication between the nations of the world. The French Metric System has already been adopted as an international system in several countries of Europe, and by the United States of America. Its introduction into British India in substitution for the existing complicated system is now in contemplation. There can be no question as to the advantage to all persons engaged in transactions with foreign countries involving weights and measures in such an international system; and considering the great advantages of the simplicity of its decimal scale, and of the relation of the measures of length, weight, and capacity to each other, as well as the adaptation of all these to the coinage, and the fact of its having been already adopted by several countries as an international system, it must be admitted that if a new system is to be adopted in this country, it can be none other than the Metric System as established in France." The whole discussion on the second reading of the Bill which resulted in its being so read by a majority of 217 against 65, is calculated to further the object in view, and as a means of diffusing information on the subject, your Committee have contributed a small amount to the expense of publishing the same in a separate form for general circulation. Owing to the lateness of the season, and the enormous amount of work before the House, Mr. Ewart agreed to withdraw the Bill, and the President of the Board of Trade urged the same course in order to give time to the Royal Commission on the Standards to make their report. The First Report of that Commission has just been issued, and your Committee are glad to find that the Commissioners have given to the Metric System considerable prominence; but it is quite evident that the object of the Commission, which is now confined to inquire into the condition of the Exchequer Standards, must be enlarged before the Commissioners can be expected to deal with the question of substituting altogether the metric for the old standards. Your Committee are pleased, however, to find from the second Report of the Warden of the Standards, that he has laid before the Commissioners the laws, ordinances, and official instructions relating to the Metric System and its establishment in France, and that he was collecting the same information as regards other countries. In connexion with the Bill in the House of Commons, your Committee learn with great regret the retirement from parliamentary life of Mr. William Ewart, whose labours in the cause have been as judicious as they were persevering and successful.

Public opinion having manifested itself so strongly in favour of the Metric System, your Committee hope that Her Majesty's Government will proceed further in the direction of introducing it as soon as it is practicable. And again would they urge that the Government should without delay adopt the Metric Weights and Measures in the Post-office, in the Dockyards, and in the Customs.

With a view to exhibit the relation of the metre to the yard, your Committee have obtained the Mural Standard described in their previous Reports. A copy of the same has been forwarded to the Ashmolean Museum in Oxford. A copy has been placed in the long room of the Custom House in London and Liverpool. One has been deposited in Dundee, and other copies have also been promised for public places in the United Kingdom. Having regard also to the efforts made by the United States of America to advance *pari passu* with this country in the introduction of the Metric System, your Committee have taken advantage of the presence in this country of Mr. Barnard, Professor of Astronomy in Harvard College, for presenting to that College a copy of the Mural Standard that it may be publicly exhibited. Such Mural Stand-

ard, with a small tablet, explaining in few words the principles of the Metric System, and the table of all Metric Weights and Measures, is well calculated to enlighten the public mind on the subject.

With the prospect that at an early period the use of the Metric System will be rendered compulsory, your Committee consider it of the highest importance to diffuse the knowledge of the same in schools and colleges, and among members of Literary and Mechanic Institutions throughout the country. One of the first steps taken by your Committee when they were first appointed, was to offer a small prize for the best school-book on the Metric System, and also to wait on the President of the Committee of Council on Education for the purpose of suggesting the introduction of the Metric System into the examination of teachers in training schools. These two objects have again been under consideration; and with a view to encourage the teaching of the Metric System, your Committee have, by the instrumentality of the Society for the Encouragement of Arts, Manufacture, and Commerce, offered three prizes of £5, £3, and £2 to such candidates who at their annual examination shall exhibit the greatest proficiency in the Metric System. A similar arrangement has also been concluded with the Committee of the British and Foreign School Society, which is connected with upwards of one thousand schools throughout England; and your Committee have with pleasure offered two prizes of £5 each, to be awarded to such Students in their Training Colleges, who shall show the most perfect acquaintance with the Metric System. And your Committee would consider it of great advantage to offer the same encouragement to the schools connected with the National Society, and the Home and Colonial School Society. The prize for the production of an elementary school-book conveying the most requisite information in the most attractive form has again been advertised.

It having come to the knowledge of the Committee that the Royal Society is now sending Dr. Carpenter and Professor Wyville Thompson in Her Majesty's Steamship 'Lightning,' under Lieutenant May, to dredge in the North Atlantic, and that a log and a sounding machine had been recently constructed by Messrs. Walker and Son of Birmingham, to measure in Metres, Kilometres, and Myriametres, your Committee have presented these two instruments to Dr. Carpenter as part of the equipment for the voyage; Dr. Carpenter agreeing to communicate the results in the terms of the Metric System.

Abroad the Metric System is making constant progress. During this year it has been adopted in North Germany, and Austria is preparing to follow in the same course. With reference to the measurement of tonnage, your Committee have learnt, that the Chancellor of the North German Confederation having moved the Federal Council that the presiding power should be authorized to open negotiations with Great Britain, and subsequently with other maritime powers, including the United States of America, for establishing an international system of ship measurement on the basis of the English system, the Federal Council resolved that the proposed system should be based upon the metrical principle instead of the English tonnage. In Spain the Metric System of Weights and Measures has been rendered compulsory from the 1st July, 1868. In the United States of America considerable progress has been made. A circular letter, signed by great numbers of schoolmasters and other teachers, advises that all books of arithmetic should contain the system. And the last meeting of the International Statistical Congress held at Florence, unanimously resolved as follows:—"The Congress of Florence, in accordance with the opinion emitted by all the previous Statistical Congresses,

recommend the universal adoption of a uniform system of weights and measures founded on the Metric Decimal System." The Congress expressed the wish that the knowledge of the same be diffused as much as possible, and with a view to that object it recommended the teaching of the system in all primary schools, the use of publications adapted to the intelligence of the greatest number, and the adoption of all the means of instruction proposed in the report of M. Jacobi adopted by the Conference held in Paris in June 1867. Some idea of the universality which the Metric System has already attained, may be found from the fact that already as many as thirteen countries, including France, Belgium, the Netherlands, Italy, the Roman States, Spain, Portugal, Greece, Mexico, Chili, Brazil, New Grenada, and other South American Republics, with an aggregate population of upwards of 146,000,000, have established one uniform Decimal System founded on the Metre. Seven more countries, with an aggregate population of 68,000,000, have also adopted parts of the same; whilst this country and the United States, having together 60,000,000, have introduced the same in a permissive manner. And in India the Government of the Bengal Presidency recommended the adoption of the Metric System as the best means for introducing simplicity and unity in the Weights and Measures of that vast Empire.

The population of and trade with the countries which use the Metric System of Weights and Measures, is as follows:—

The amount of trade being exracted from the annual accounts of the Board of Trade for 1866.

Countries where the Metric System is obligatory.

Countries.	Population.	Real Value of Imports.	Declared value of Exports of British, Foreign, and Colonial Merchandise.	Total Trade.
France, with Algeria	40,500,000	£37,000,000	£26,600,000	£63,600,000
Belgium	5,000,000	7,900,000	6,800,000	14,700,000
Netherlands	23,000,000	11,800,000	16,800,000	28,600,000
Italy	24,000,000	3,800,000	6,900,000	10,700,000
Roman States	700,000			
Spain and Colonies	21,000,000	10,000,000	6,800,000	16,800,000
Portugal and Colonies	8,000,000	3,200,000	2,600,000	5,800,000
Greece	1,200,000	900,000	900,000	1,800,000
Mexico	8,200,000	300,000	1,300,000	1,600,000
Chili	1,600,000	2,900,000	1,900,000	4,800,000
Brazil	8,000,000	7,200,000	7,300,000	14,500,000
New Grenada	2,200,000	1,500,000	3,000,000	4,500,000
Other South American Republics	3,000,000	6,500,000	5,000,000	11,500,000
	146,400,000	£93,000,000	£85,900,000	£178,900,000

Countries where the Metric System has been only partially introduced.

Switzerland	2,500,000			
Baden	1,400,000			
Prussia	18,000,000			
Bavaria	4,500,000			
Wurtemburg	2,200,000	£18,800,000	£24,800,000	£43,600,000
Denmark	3,000,000	2,300,000	2,100,000	4,400,000
Austria	37,000,000	1,300,000	1,000,000	2,300,000
	68,600,000	£22,400,000	£27,900,000	£50,300,000

TABLE (*continued*).

Countries where it is permissive.

Countries.	Population.	Real Value of Imports.	Declared value of Exports of British, Foreign, and Colonial Merchandise.	Total Trade.
United Kingdom	29,000,000			
United States of America	31,000,000	£46,800,000	£31,800,000	£78,600,000
	60,000,000	£46,800,000	£31,800,000	£78,600,000

Summary.

Countries where it is obligatory	146,400,000	£93,000,000	£85,900,000	£178,900,000
In part only	68,600,000	22,400,000	27,900,000	50,300,000
Permissive	60,000,000	46,800,000	31,800,000	78,600,000
	275,000,000	£162,200,000	£145,600,000	£307,800,000
Total Trade	...	£295,000,000	£239,000,000	£534,000,000
Percentage of the Trade with Countries using the Metric System	...	54	61	57

As regards International Coinage, your Committee have already reported the result of the two Conferences which were held in Paris in June 1867. A report of the official conference having been presented to Her Majesty's Government, a Royal Commission was issued to consider and report upon the recommendations of the Conference, and their adaptability to the circumstances of the United Kingdom, and whether it would be desirable to make any and what changes in the coinage of the United Kingdom, in order to establish, either wholly or partially, such uniformity as the Conference had in contemplation. The Commissioners have completed their labours and presented their Report to Parliament, but the same has not yet been published. A report of the unofficial International Conference on Weights, Measures, and Coins has been communicated by Professor Leone Levi to Lord Stanley and was laid before Parliament. During the year a Bill was presented to the United States Congress for placing their coinage in direct relation to the French, by reducing the value of the half eagle $3\frac{1}{2}$ per cent., so that it may be worth 25 francs. The Bill was read a second time, and a clause was inserted granting compensation to holders for the difference between the value of the existing coinage and that of the future currency; but the Bill stands over for consideration, probably till the Report of the Royal Commission in this country is made known. Canada has introduced a Bill to the same effect. Spain has engaged to coin gold pieces of 10 francs and 25 francs. Roumania has adopted the system of the Convention. The German Parliament passed a resolution in favour of a decimal currency. Austria has entered into the Convention. And at the International Statistical Congress held at Florence, the following resolutions were passed in favour of such uniformity:—

1. The Congress recommend the adoption of a uniform monetary system in all States on the basis of a gold standard, assisted by silver coin, also uniform everywhere, for external circulation.

2. The Congress entrusts to a Central Committee the duty to gather, classify, and publish in the most known journals of Europe the data of the production, and immediate diffusion over the markets of the Old and New World of the precious metals, and of the mintage operations of different States.

3. The Congress recommends the study and development of the laws under which the precious metals, whether in coin or bullion, move from place to place.

4. It is desirable to define according to the dictates of science, and the character of the different institutions, the paper money which represent or replace the coinage.

5. It is desirable to have periodical or bimonthly accounts of the variations in the amount of such, and of the relation which exists between such paper money and the precious metal.

7. It is desirable to endeavour to obtain, if possible, statistical data of the circulation not included in paper money or other instruments of credit.

A schedule of the required data on such subjects was also furnished as follows:—

Production, distribution, and consumption or use of the precious metals.

1. Production.—Gold and silver: indicate as respects gold if it has been obtained by extraction or by washing. Note the place or centre of production. Give the weight and value of annual production.

2. Distribution, Imports, and Exports.—Countries which send and receive by sea or land. Give the quantity and kind imported and exported, whether ingots, coins, objects of art, or simple industrial product. Prepare a monthly table of imports and exports with such details.

3. Consumption or use.—Weight and value of coinage pieces of every kind having legal course in the State issued by the Mint. Amount of old coin withdrawn. Quantity of the precious metal consumed in gold and silver work and jewelleries. Quantity and value absorbed for industrial uses of every kind. Valuation of annual loss.

As the Report of the Royal Commissioners on International Coinage will be soon published, your Committee defer pronouncing any opinion on the subject for the present. The great object for which your Committee has been formed is steadily advancing, and your Committee entertain the firm conviction that notwithstanding all opposing influences, it will be eventually and at no great distance, fully and successfully carried out.

Committee for the purpose of promoting the extension, improvement, and harmonic analysis of Tidal Observations. Consisting of Sir WILLIAM THOMSON, *LL.D., F.R.S.*, Prof. J. C. ADAMS, *F.R.S*, The ASTRONOMER ROYAL, *F.R.S.*, J. F. BATEMAN, *F.R.S.*, Admiral Sir EDWARD BELCHER, *K.C.B.*, T. G. BUNT, Staff-Commander BURDWOOD, *R.N.*, WARREN DE LA RUE, *F.R.S.*, Prof. FISCHER, *F.R.S.*, J. P. GASSIOT, *F.R.S.*, Prof. HAUGHTON, *F.R.S.*, J. R. HIND, *F.R.S.*, Prof. KELLAND, *F.R.S.*, Staff-Captain MORIARTY, *C.B.*, J. OLDHAM, *C.E.*, W. PARKES, M. Inst. C.E., Prof. B. PRICE, *F.R.S.*, Rev. C. PRITCHARD, *LL.D., F.R.S.*, Prof. RANKINE, *LL.D., F.R.S.*, Captain RICHARDS, *R.N., F.R.S.*, Dr. ROBINSON, *F.R.S.*, Lieut.-General SABINE, *President of the Royal Society*, W. SISSONS, Prof. STOKES, *D.C.L., F.R.S.*, T. WEBSTER, *M.A., F.R.S., and* Prof. FULLER, *M.A., and* J. F. ISELIN, *M.A., Secretaries.*

Report by Sir W. THOMSON.

THE following Circular, issued to the Committee in December 1867, explains the plan of procedure proposed and the progress made in the investigations up to that date:—

December 1867.

Sir,—We beg to invite your attention to the following statement, drawn up by Sir William Thomson, for the purpose of explaining to the members of the Committee on Tidal Observations, the special objects he had in view in moving the appointment of that Committee.

We shall feel obliged by your favouring us at your earliest convenience with any remarks on this statement which may occur to you, and with any further suggestions you may wish to lay before the Committee.

We are, Sir,

Your obedient Servants,

Frederick Fuller,
J. F. Iselin,
} *Secretaries.*

[§§ 1–11 of what follows is, with a few corrections, the statement which was circulated in December. The foot-notes in brackets [ ] have been added this day, Aug. 19, 1868.]

1. The chief, it may be almost said the only, practical conclusion deducible from, or at least hitherto deduced from, the dynamical theory is, that the height of the water at any place may be expressed as the sum of a certain number of simple harmonic functions* of the time, of which the periods are known, being the periods of certain components of the sun's and moon's motions†. Any such harmonic term will be called a tidal constituent, or sometimes, for brevity, a tide. The expression for it in ordinary analytical notation is $A \cos nt + B \sin nt$; or $R \cos (nt - \epsilon)$, if $A = R \cos \epsilon$, and $B = R \sin \epsilon$; where t denotes time measured in any unit from any era, n the corresponding angular velocity (a quantity such that $\frac{2\pi}{n}$ is the period of the function), R and ϵ the amplitude and the epoch, and A and B coefficients immediately determined from observation by the proper harmonic analysis (which consists virtually in the method of least squares applied to deduce the most probable values of these coefficients from the observations).

2. The chief tidal constituents in most localities, indeed in all localities where the tides are comparatively well known, are those whose periods are twelve mean lunar hours, and twelve mean solar hours respectively. Those which probably stand next in importance are the tides whose periods are approximately twenty-four hours. The former are called the lunar semidiurnal tide, and solar semidiurnal tide; the latter, the lunar diurnal tide and the solar diurnal tide‡. There are, besides, the lunar fortnightly tide and the solar semiannual tide§. The diurnal and the semidiurnal tides have inequalities depending on the excentricity of the moon's orbit round the earth, and of the earth's round the sun, and the semidiurnal have inequalities depending on the varying declinations of the two bodies. Each such inequality of any one of the chief tides may be regarded as a smaller superimposed tide of period approximately equal; producing, with the chief tide, a compound effect which corresponds precisely to the discord of two simple harmonic notes in music approximately in unison with one another. These

* See Thomson and Tait's 'Natural Philosophy,' §§ 53, 54.

† See Laplace, 'Mécanique Céleste,' liv. iv. § 16. Airy's 'Tides and Waves,' § 585.

‡ See Airy's 'Tides and Waves,' §§ 46, 49; or Thomson and Tait's 'Natural Philosophy,' § 808.

§ See Airy's 'Tides and Waves,' § 45; or Thomson and Tait's 'Natural Philosophy,' § 880.

constituents may be called for brevity elliptic and declinational tides. But two of the solar elliptic diurnal tides thus indicated have the same period, being twenty-four mean solar hours. Thus we have in all twenty-three tidal constituents:—

		Coefficients of t in arguments. Lunar.	Solar.
The lunar monthly and solar annual (elliptic) .	2	σ	η
The lunar fortnightly and solar semiannual (declinational)	2	2σ	2η
The lunar and solar diurnal (declinational) .	4	γ $\gamma-2\sigma$	γ $\gamma-2\eta$
The lunar and solar semidiurnal	2	$2(\gamma-\sigma)$	$2(\gamma-\eta)$
The lunar and solar elliptic diurnal . . .	7	$\gamma+\sigma-\varpi$ $\gamma-\sigma+\varpi$ $\gamma-\sigma-\varpi$ $\gamma-3\sigma+\varpi$	$\gamma+\eta$ $\gamma-\eta$ $\gamma-\eta$ $\gamma-3\eta$
The lunar and solar elliptic semidiurnal . .	4	$2\gamma-\sigma-\varpi$ $2\gamma-3\sigma+\varpi$	$2\gamma-\eta$ $2\gamma-3\eta$
The lunar and solar declinational semidiurnal	2	2γ	2γ

3. Here γ denotes the angular velocity of the earth's rotation, and σ, η, ϖ those of the moon's revolution round the earth, of the earth's round the sun, and of the progression of the moon's perigee. The motion of the first point of Aries, and of the earth's perihelion, are neglected. It is almost certain that the slow *variation* of the lunar declinational tides due to the retrogression of the nodes of the moon's orbit, may be dealt with with sufficient accuracy according to the equilibrium method; and the inequalities produced by the perturbations of the moon's motion are probably insensible. But each one of the twenty-three tides enumerated above is certainly sensible on our coasts. And there are besides, as Laplace has shown, very sensible tides depending on the fourth power of the moon's parallax*, the investigation of which must be included in the complete analysis now suggested, although for simplicity they have been left out of the preceding schedule. The amplitude and the epoch of each tidal constituent for any part of the sea is to be determined by observation, and cannot be determined except by observation. But it is to be remarked that the period of one of the lunar diurnal tides agrees with that of one of the solar diurnal tides, being twenty-four sidereal hours; and that the period of one of the semidiurnal lunar declinational tides agrees with that of one of the semidiurnal solar declinational tides, being twelve sidereal hours. Also that the angular velocities $\gamma-\sigma+\varpi$ and $\gamma-\sigma-\varpi$ are so nearly equal, that observations through several years must be combined to distinguish the two corresponding elliptic diurnal tides. Thus the whole number of constituents to be determined by one year's observation is twenty. The forty constants specifying these twenty constituents are probably each determinable, with considerable accuracy, from the data afforded in the course of a year by a good self-registering tide-gauge, or from accurate personal observations taken at equal short intervals of time, hourly for instance. Each lunar declinational tide varies from a minimum to a maximum, and back to a minimum,

[* The chief effect of this at any one station is a *ter-diurnal* lunar tide, or one whose period is eight lunar hours. A probable indication of this has been obtained from the Ramsgate tidal diagrams of 1864. See § 22 below.]

every nineteen years or thereabouts (the period of revolution of the line of nodes of the moon's orbit). Observations continued for nineteen years will give the amount of this variation with considerable accuracy, and from it the proportion of the effect due to the moon will be distinguished from that due to the sun. It is probable that thus a somewhat accurate evaluation of the moon's mass may be arrived at.

4. The methods of reduction hitherto adopted*, after the example set by Laplace and Lubbock, have consisted chiefly, or altogether, in averaging the heights and times of high water and low water in certain selected sets of groups. Laplace commenced in this way, as the only one for which observations made before his time were available. How strong the tendency is to pay attention chiefly or exclusively to the times and heights of high and low water, is indicated by the title printed at the top of the sheets used by the Admiralty to receive the automatic records of the tide-gauges; for instance, "Diagram, showing time of high and low water at Ramsgate, traced by the tide-gauge." One of the chief practical objects of tidal investigation is, of course, to predict the time and height of high water; but this object is much more easily and accurately attained by the harmonic reduction of observations not confined to high or low water. The best arrangement of observations is to make them at equi-distant intervals of time, and to observe simply the height of the water at the moment of observation irrespectively of the time of high or low water. This kind of observation will even be less laborious and less wasteful of time in practice than the system of waiting for high or low water, and estimating by a troublesome interpolation the time of high water, from observations made from ten minutes to ten minutes, for some time preceding it and following it. The most *complete* system of observation is, of course, that of the self-registering tide-gauge which gives the height of the water-level above a fixed mark every instant. But direct observation and measurement would probably be more *accurate* than the records of the most perfect tide-gauge likely to be realized.

5. One object proposed for the Committee is to estimate the accuracy, both as to time and as to scale of height, attained by the best self-registering tide-gauges at present in use, and (taking into account also the relative costliness of different methods) to come to a resolution as to what method should be recommended when new sets of observations are set on foot in any place. In the mean time the following method of observation is recommended as being more accurate and probably less expensive, than the plan of measurement on a stem attached to a float, often hitherto followed where there is no self-registering tide-gauge. A metal tube, which need not be more than 2 or 3 inches in diameter, is to be fixed vertically, in hydrostatic communication, by its lower end, with the sea. A metal scale graduated to centimetres (or to hundredths of a foot, if preferred) is to be let down by the observer in the middle of the tube until it touches the liquid surface; and a fixed mark attached to the top of the tube then indicates the reading which is to be taken. Attached to the measuring-scale must be one or more pistons fitting loosely in the tube and guiding the rod so that it may remain, as nearly as may be, in the centre of the tube. The observer will know when its lower end is precisely at the level of the surface of the liquid, by aid of an electric circuit completed through a single galvanic cell, the coil of a common telegraph

* See 'Directions for reducing tidal observations,' by Staff-Commander Burdwood, London, 1865, published by the Admiralty; also Professor Haughton on the "Solar and Lunar Diurnal Tides on the Coast of Ireland," Transactions of the Royal Irish Academy April for 1854.

"detector," the metal measuring-scale, the liquid, and the metal tube*. By this method it will be easy to test the position of the water-level truly to the tenth of an inch. It is not probable that tidal observations hitherto made, whether with self-registering tide-gauges or by direct observations, have had this degree of accuracy; and it is quite certain that a proper method of reduction will take advantage of all the accuracy of the plan now proposed†.

6. An observation made on this plan every three hours, from day to day for a month, would probably suffice to give the data required for nautical purposes for any harbour. It is intended immediately to construct an apparatus of the kind, and give it a trial for a few weeks at some convenient harbour, and if the plan prove to be successful and convenient, it will come to be considered whether observations made at every hour of the day and night might not, all things considered (accuracy, economy, and sufficiency for all scientific wants), be preferable to a self-registering tide-gauge.

7. One of the most interesting of the questions that can be proposed in reference to the tides is, how much is the earth's angular velocity diminished by them from century to century? although the direct determination of this amount, or even a rough estimate of it, can scarcely be hoped for from tidal observation, as the data for the quadrature required could not be had directly. But accurate observation of amounts and times of the tide on the shores of continents and islands of all seas might, with the assistance of improved dynamical theory, be fully expected to supply the requisite data for at least a rough estimate. In the mean time it may be remarked that one very important point of the theory, discovered by Airy‡, affords a ready means of disentangling some of the complicacy presented by the distribution of the times of high water in different places, and will form a sure foundation for the practical estimate of a definite *part* of the whole amount of retardation, when the times of spring tides and neap tides are better known for all parts of the sea than they are at present. To understand this, imagine a tidal spheroid to be constructed by drawing an infinite number of lines perpendicular to the actual mean sea-level continued under the solid parts of the earth which lie above the sea, and equal to the spherical harmonic term or Laplace's function, of the second order, in the development of a discontinuous function equal to the height of the sea at any point above the mean level where there is sea, and equal to zero for all parts of the earth's surface occupied by dry land. This spheroid we shall call for brevity the mean tidal spheroid (lunar or solar as the case may be, or luni-solar when the heights due to moon and sun are added). The fact that the lunar semidiurnal tide is, over nearly the whole surface of the sea, greater than the solar, in a greater ratio than that of the generating force, renders it almost certain that the longest axes of the mean luni-tidal and soli-tidal spheroids would each of them lie in the meridian 90° from the disturbing body (moon or sun) if the motion of the water were unopposed by friction; or, which means the same thing, that there would be on the average of the whole seas, *low* water when the disturbing body crosses the meridian, were the hypothesis of no friction fulfilled. But, as Airy has shown, the tendency of friction is to *advance* the times of low and high water

[* Instead of the galvanic detector, a hydraulic method may be found preferable in some places. The latter consists in using a stiff tube of half inch diameter or so, instead of the solid metal measuring-bar, and testing whether its lower end is above or below the level of the water by suction at the upper end.]

[† The "Clyde Trust" have given permission to try this method at a convenient place in the harbour of Glasgow. It is probable that it will also be tried in the harbour of Belfast.]

‡ See Airy's 'Tides and Waves,' § 459.

when the depth and shape of the ocean are such as to make the time of low water on the hypothesis of no friction be that of the disturbing body's transit. Now, the well-known fact that the spring tides on the Atlantic coast of Europe are about a day or a day and a half after full and change (the times of greatest force), and that through nearly the whole sea they are probably more or less behind these times, which Airy long ago maintained* to be a consequence of friction, would prove that the crowns of the luni-tidal spheroid are in advance of those of the soli-tidal spheroid; and therefore that those of the latter are less advanced by friction than those of the former. It is easily conceived that a knowledge of the heights of the tides and of the intervals between the spring tides and the times of greatest force, somewhat more extensive than we have at present, would afford data for a rough estimate of the proper mean amount of the average interval in question, that is, of the interval between the times of high water of the mean luni-tidal and mean soli-tidal spheroids. The whole moment of the couple retarding the earth's rotation, in virtue of the lunar tide, must be something more than that calculated on the hypothesis that the obliquity of the mean luni-tidal spheroid is only equal to the hour-angle corresponding to that interval of time.

8. We know, however, but little at present regarding the actual time of the spring tides in different parts of the ocean, and it is not even quite certain, although, as Airy remarks, it is extremely probable, that in the southern seas they take place at an interval *after* the full and change, although it may be at a less interval than on the Atlantic coast of Europe. There must be observations on record (such as those of Sir Thomas Maclear at the Cape of Good Hope, which Staff-Commander Burdwood showed me in the Hydrographical Office of the Admiralty) valuable for determining this very important element, for ports on all seas where any approach to a knowledge of the laws of the tides has been made.

To collect information on this point from all parts of the world will be one of the most interesting parts of the work of the Committee.

9. Another very interesting subject for inquiry is the lunar fortnightly, or solar semiannual, tide, the determination of which will form part of the complete harmonic reduction of proper observations made for a sufficient time. The amounts of these tides must be very sensible in all places remote from the zero line† of either northern or southern hemisphere; unless the solid earth yields very sensibly in its figure to the tide generating force‡. Thus it has been calculated that if the earth were perfectly rigid, the sum of the rise from lowest to highest at Teneriffe, and simultaneous fall from highest to lowest at Iceland, in the lunar fortnightly tides, would amount to 4·5 inches. The preliminary trials of plans for harmonic reduction referred to below, make it almost certain that hourly observations, continued for a month at two such stations as these, would determine the amount of the fortnightly tide to a fraction of an inch, in ordinarily favourable circumstances as to barometric disturbance, and so would give immediate data for answering, to some degree of accuracy, the question how much does the solid earth really yield to the tide generating force?

10. A year before proposing to Section A of the British Association the appointment of a Committee to promote tidal investigation, I applied through my friend Staff-Commander Moriarty, R.N., for a year's tidal diagrams of

* See Airy's 'Tides and Waves,' § 544.

† Thomson and Tait's 'Natural Philosophy,' § 810.

‡ "On the Rigidity of the Earth," W. Thomson, Trans. R.S., May 1862; or Thomson and Tait's 'Natural Philosophy,' §§ 832–849.

any trustworthy tide-gauge; and, through his kind assistance, I accordingly received from Staff-Commander Burdwood, R.N., those of the Royal Harbour of Ramsgate for 1864. From the beginning of last winter till the present time I have been engaged in the reduction of these observations, chiefly assisted by Mr. Ebenezer Maclean, but also by Mr. James Smith and Mr. William Ross, students of the Natural-Philosophy Class of Glasgow University, last Session, who volunteered to perform the laborious processes of measurement and calculation required. The heights above a certain point near the bottom of the scale, chosen to avoid negative quantities, were measured from the diagrams for noon and midnight 6 P.M. and A.M., 3 P.M. and A.M., 9 A.M. and P.M.; but after some preliminary calculations had shown what valuable results might be expected, the measurement was made for every mean solar hour of the year, and the numbers written down in a book, with a page for each day. Certain averagings of these results, arranged in proper groups, were then made, and somewhat closely approximate determinations of the amplitude and epoch of the solar semidiurnal and lunar semidiurnal tides were deduced. I also found very decided indications of an *annual* rise and fall, which seemed to exceed the amount of the solar semiannual tide, and to make the mean level very sensibly higher in autumn than in spring, an effect probably to be accounted for by an annual period in the amount of water received into the sea by drainage and the melting of ice, and from the direct fall of rain into it. With these indications of what might be expected from a thorough reduction of tidal observations according to the harmonic plan, I felt justified in bringing the subject before the British Association and proposing that the cooperation of a Committee should be invited, and a grant of money made to defray expenses which might be found necessary for carrying on the several parts of the investigation proposed. Acting on the advice of the Astronomer Royal, I have put the work of continuing the computations for the Ramsgate observations into the hands of a skilled calculator, Mr. E. Roberts, recommended to me by Mr. Farley of the Nautical Almanac Office, for this purpose. With his very able assistance I hope soon to have the harmonic analysis completed for the year's observations now in his hands; and I shall lose as little time as possible in communicating the results to the Committee. I shall keep in view the trial (with which I commenced work on these observations) to find how much of valuable results can be obtained from a comparatively small number of observations, for instance, observations every three hours of the twenty-four, instead of every hour, or every three hours of the day half of the twenty-four, for the purpose of learning how to reduce, as far as possible, the labour and inconvenience imposed upon those to whom may be committed the execution of observations taken in future according to advice from this Committee.

11. Probably the best personal observations that have ever been made on the tides are those described by Captain Sir James Clark Ross, R.N., in the Philosophical Transactions for June 1854, as having been made by the officers and petty officers of H.M. ships 'Enterprise' and 'Investigator,' every hour of the twenty-four, for nine months, commencing November 1st, 1848, in Port Leopold. A full harmonic reduction of these observations, and of the simultaneously observed heights of the barometer, must, as early as possible, be executed by this Committee.

12. A beautiful synthesis of the complex dynamical action to which the tides are due, imagined by Laplace, will be used in this Report to enable us to avoid circumlocution. A number of fictitious stars ("astres fictifs") are assumed to move, each uniformly in the plane of the earth's equator, with

angular velocities small in comparison with that of the earth's rotation, so that the diurnal period of each relatively to the earth is something not very different from the lunar or solar twenty-four hours. Each one of the approximately semidiurnal tides (§ 2) is produced by one alone of these fictitious stars.

13. One of the fictitious stars is what is commonly called in England the "mean sun," being that point of the celestial sphere in the plane of the earth's equator whose hour-angle is equal to mean solar time. For brevity we shall call it S. Another of them might be the "mean moon" similarly defined (called M); but, to allow the same Tables (§§ 14, 15) to be used for the reduction of tidal observations of different years, we shall take it as a point moving in the plane of the earth's equator, with an angular velocity equal to the mean angular velocity of the moon, and set for each year so that its hour-angle is $350°\cdot40$ at 0^h, January 1. Four others complete the number of the fictitious stars to be used in this Report*; they will be designated K, L, N, O.

K might be the first point of Aries, but, for the same reason, will be taken as a point in the plane of the earth's equator, with constant right ascension for each year, such that its hour-angle is $6°\cdot25$ at 0^h, January 1.

O is a fictitious star whose right ascension increases twice as fast as that of the mean moon, and which is so set for each year that its hour-angle is $334°\cdot54$ at 0^h, January 1. L and N are fictitious stars whose rates of increase of right ascension are respectively greater than, and less than, that of the mean moon, by a difference equal to half that of the mean moon relatively to her perigee. Thus, if the motion of the moon's perigee were neglected, the rate of increase of right ascension of L would be half that of N, and the arithmetic mean of that of N and O respectively; or, as the right ascension of K is constant, the rates of increase of right ascension of L, M, N, O would be equi-different.

14. Thus, according to the preceding notation, the rates of increase of right ascension of K, L, M, N, O are respectively

$$0, \quad \tfrac{1}{2}(\sigma+\varpi), \quad \sigma, \quad \tfrac{1}{2}(3\sigma-\varpi), \quad 2\sigma.$$

Relatively to the meridian of the earth, their angular velocities are—

$$\gamma, \quad \gamma-\tfrac{1}{2}\sigma-\tfrac{1}{2}\varpi, \quad \gamma-\sigma, \quad \gamma-\tfrac{3}{2}\sigma+\tfrac{1}{2}\varpi, \quad \gamma-2\sigma.$$

Unless the contrary is stated we shall always suppose these angular velocities to be reckoned in degrees and decimals of a degree per mean solar hour. Thus reckoned their values are—

$$\sigma=\cdot549015, \quad \gamma=15\cdot04108, \quad \gamma-\tfrac{1}{2}\sigma-\tfrac{1}{2}\varpi=14\cdot76425, \quad \gamma-\sigma=14\cdot49206,$$
$$\gamma-\tfrac{3}{2}\sigma+\tfrac{1}{2}\varpi=14\cdot21988, \quad \gamma-2\sigma=13\cdot94305.$$

If t denote time reckoned in mean solar hours from the 0^h January 1 of the year,

$$\gamma t, \quad (\gamma-\tfrac{1}{2}\sigma-\tfrac{1}{2}\varpi)t, \quad (\gamma-\sigma)t \text{ \&c.}$$

will be the hour-angles of the fictitious stars. These have been calculated by successive additions for each integral mean solar hour of the year, and subtraction of 360 every time a number exceeding 360 has been reached; and the results have been tabulated. Preceding each hour-angle, the number which, multiplied by 15, most nearly agrees with it has been written. The following is a specimen page for two days of the year, of the Table thus formed:—

* Others may be introduced for the lunar elliptic diurnal, and for the declinational and elliptic disturbances of the solar tide, not yet fully investigated.

JANUARY 8–9, 1864.

S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
	°	°	°	°	°
0. 0	**1.** 13·15	**10.** 143·22	**18.** 265·07	**2.** 26·90	**10.** 156·97
1. 15	**2.** 28·19	**11.** 157·98	**19.** 279·56	**3.** 41·12	**11.** 170·91
2. 30	**3.** 43·23	**12.** 172·75	**20.** 294·05	**4.** 55·34	**12.** 184·86
3. 45	**4.** 58·27	**13.** 187·51	**21.** 308·55	**5.** 69·56	**13.** 198·80
4. 60	**5.** 73·31	**13.** 202·28	**22.** 323·04	**6.** 83·78	**14.** 212·74
5. 75	**6.** 88·36	**14.** 217·04	**23.** 337·53	**7.** 98·00	**15.** 226·68
6. 90	**7.** 103·40	**15.** 231·80	**23.** 352·02	**7.** 112·22	**16.** 240·63
7. 105	**8.** 118·44	**16.** 246·57	**0.** 6·51	**8.** 126·44	**17.** 254·57
8. 120	**9.** 133·48	**17.** 261·33	**1.** 21·01	**9.** 140·66	**18.** 268·51
9. 135	**10.** 148·52	**18.** 276·10	**2.** 35·50	**10.** 154·88	**19.** 282·46
10. 150	**11.** 163·56	**19.** 290·86	**3.** 49·99	**11.** 169·10	**20.** 296·40
11. 165	**12.** 178·60	**20.** 305·63	**4.** 64·48	**12.** 183·32	**21.** 310·34
12. 180	**13.** 193·64	**21.** 320·39	**5.** 78·97	**13.** 197·54	**22.** 324·29
13. 195	**14.** 208·68	**22.** 335·15	**6.** 93·47	**14.** 211·76	**23.** 338·23
14. 210	**15.** 223·73	**23.** 349·92	**7.** 107·96	**15.** 225·98	**23.** 352·17
15. 225	**16.** 238·77	**0.** 4·68	**8.** 122·45	**16.** 240·20	**0.** 6·11
16. 240	**17.** 253·81	**1.** 19·45	**9.** 136·94	**17.** 254·42	**1.** 20·06
17. 255	**18.** 268·85	**2.** 34·21	**10.** 151·44	**18.** 268·64	**2.** 34·00
18. 270	**19.** 283·89	**3.** 48·98	**11.** 165·93	**19.** 282·86	**3.** 47·94
19. 285	**20.** 298·93	**4.** 63·74	**12.** 180·42	**20.** 297·08	**4.** 61·89
20. 300	**21.** 313·97	**5.** 78·50	**13.** 194·91	**21.** 311·30	**5.** 75·83
21. 315	**22.** 329·01	**6.** 93·27	**14.** 209·40	**22.** 325·52	**6.** 89·77
22. 330	**23.** 344·05	**7.** 108·03	**15.** 223·90	**23.** 339·74	**7.** 103·72
23. 345	**0.** 359·10	**8.** 122·80	**16.** 238·39	**0.** 353·96	**8.** 117·66
0. 0	**1.** 14·14	**9.** 137·56	**17.** 252·88	**1.** 8·18	**9.** 131·60
1. 15	**2.** 29·18	**10.** 152·33	**18.** 267·37	**1.** 22·40	**10.** 145·55
2. 30	**3.** 44·22	**11.** 167·09	**19.** 281·86	**2.** 36·62	**11.** 159·49
3. 45	**4.** 59·26	**12.** 181·85	**20.** 296·36	**3.** 50·84	**12.** 173·43
4. 60	**5.** 74·30	**13.** 196·62	**21.** 310·85	**4.** 65·06	**12.** 187·37
5. 75	**6.** 89·34	**14.** 211·38	**22.** 325·34	**5.** 79·28	**13.** 201·32
6. 90	**7.** 104·38	**15.** 226·15	**23.** 339·83	**6.** 93·50	**14.** 215·26
7. 105	**8.** 119·42	**16.** 240·91	**0.** 354·32	**7.** 107·72	**15.** 229·20
8. 120	**9.** 134·47	**17.** 255·68	**1.** 8·82	**8.** 121·94	**16.** 243·15
9. 135	**10.** 149·51	**18.** 270·44	**2.** 23·31	**9.** 136·16	**17.** 257·09
10. 150	**11.** 164·55	**19.** 285·20	**3.** 37·80	**10.** 150·38	**18.** 271·03
11. 165	**12.** 179·59	**20.** 299·97	**3.** 52·29	**11.** 164·60	**19.** 284·98
12. 180	**13.** 194·63	**21.** 314·73	**4.** 66·78	**12.** 178·82	**20.** 298·92
13. 195	**14.** 209·67	**22.** 329·50	**5.** 81·28	**13.** 193·04	**21.** 312·86
14. 210	**15.** 224·71	**23.** 344·26	**6.** 95·77	**14.** 207·26	**22.** 326·80
15. 225	**16.** 239·75	**0.** 359·02	**7.** 110·26	**15.** 221·48	**23.** 340·75
16. 240	**17.** 254·79	**1.** 13·79	**8.** 124·75	**16.** 235·70	**0.** 354·69
17. 255	**18.** 269·84	**2.** 28·55	**9.** 139·24	**17.** 249·92	**1.** 8·63
18. 270	**19.** 284·88	**3.** 43·32	**10.** 153·74	**18.** 264·14	**2.** 22·58
19. 285	**20.** 299·92	**4.** 58·08	**11.** 168·23	**19.** 278·36	**2.** 36·52
20. 300	**21.** 314·96	**5.** 72·85	**12.** 182·72	**20.** 292·58	**3.** 50·46
21. 315	**22.** 330·00	**6.** 87·61	**13.** 197·21	**20.** 306·80	**4.** 64·41
22. 330	**23.** 345·04	**7.** 102·37	**14.** 211·71	**21.** 321·02	**5.** 78·35
23. 345	**0.** 0·08	**8.** 117·14	**15.** 226·20	**22.** 335·24	**6.** 92·29

The "S" hours are reckoned from mean noon of each day.

15. The Committee recommend that this Table should be printed for general use in the reduction of tide observations. A second Table, which will be described later, has also been drawn up. Part of it, amounting to about $\frac{2}{6\times 5}$ of the whole, is given here as a specimen. By aid of these

TABLE OF COMPARATIVE MEAN SOLAR AND MEAN LUNAR HOURS.

Hour S $(\gamma-\eta)$.	Hour M $(\gamma-\sigma)$.																						
	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
0.	16	14	16	13	16	14	17	15	16	16	16	17	15	17	15	17	15	17	14	16	14	15	15	14
1.	15	15	15	15	14	15	15	16	15	17	15	17	16	16	16	16	16	16	16	14	16	14	16	14
2.	13	16	14	15	15	14	16	14	16	15	17	15	17	15	17	15	16	17	15	17	14	16	14	16
3.	15	14	15	14	16	14	15	15	15	16	15	16	16	16	16	16	15	17	16	16	16	15	16	14
4.	14	16	13	16	14	16	13	16	14	16	15	15	17	15	17	15	17	15	17	15	17	15	16	15
5.	15	15	15	14	16	14	15	14	15	15	15	15	16	16	16	17	15	17	15	16	16	16	15	16
6.	16	14	16	14	15	15	14	16	13	16	14	16	14	17	15	17	16	16	16	15	17	15	17	15
7.	15	16	14	15	14	15	15	15	15	14	16	14	16	14	16	16	16	16	16	16	16	17	15	17
8.	16	15	16	14	16	13	16	14	16	14	15	15	15	15	14	17	15	17	15	17	15	17	16	16
9.	16	16	16	16	14	16	13	16	14	15	14	15	15	15	15	15	17	15	17	15	17	15	16	16
10.	15	17	15	17	15	15	15	14	15	14	16	13	16	14	16	14	16	16	16	16	15	17	15	17
11.	17	15	17	15	17	14	15	15	14	16	14	16	13	16	14	16	13	16	16	16	17	15	17	15
12.	16	16	16	16	15	17	14	16	14	15	15	15	15	14	15	15	15	13	17	15	17	16	16	16
13.	15	16	17	15	17	15	17	14	16	13	16	14	15	15	14	16	14	16	13	17	15	17	15	17
14.	17	15	17	16	16	16	16	16	15	15	14	15	14	16	14	15	15	15	15	14	16	16	16	15
15.	15	17	15	17	15	17	15	16	17	14	16	13	16	14	16	13	16	14	16	14	14	17	15	17
16.	17	15	17	15	16	16	16	15	17	16	15	15	14	16	14	15	14	15	14	16	14	15	16	16
17.	17	16	15	17	15	17	15	17	15	17	15	16	14	15	15	14	16	13	16	14	16	13	16	15
18.	16	16	16	16	16	16	17	15	17	15	16	16	15	14	15	15	15	15	14	16	14	16	13	15
19.	16	15	17	15	17	15	17	16	16	16	15	17	15	16	13	16	14	16	14	15	15	14	16	13
20.	14	16	15	17	15	16	16	16	16	16	16	16	17	15	16	13	16	14	15	14	15	15	15	15
21.	14	15	15	16	16	15	17	15	17	15	17	15	17	16	16	15	14	15	14	16	13	16	14	16
22.	16	13	15	15	16	17	15	17	15	17	15	17	15	16	16	16	15	14	16	14	16	13	16	14
23.	14	16	13	16	14	17	16	16	16	16	16	16	16	15	17	15	17	15	15	15	15	15	14	15

Tables, with a set of rules for use to be appended, it is anticipated that an accurate and extended reduction of tidal observations for any sea and any complete year will become a very simple matter. For the present we confine ourselves to the statement of what has actually been done for the year 1864 and the harbour of Ramsgate.

16. A datum line 10 feet below the previously supposed mean level was chosen*, and the height of the curves, marked by the self-registering tide-guage, was measured from this datum line in feet and decimals of a foot for each integral mean solar hour of the year, and entered in the Table. A period of $369^d\ 3^h$, or rather more than a year, was taken as being to the nearest hour twelve and a half lunations or twenty-five periods of spring and neap tides, and therefore giving a least possible amount of influence of the mean lunar and solar semidiurnal tides, each on the sets of averages used in the calculation of the other. A period of $358^d\ 6^h$ was chosen, for a similar reason, for the lunar elliptic semidiurnal tides.

17. These averages were taken according to the following rule. First for the S tides, twenty-four means of the heights at $0^h, 1^h, 2^h, \ldots 23^h$ of S hours (or ordinary mean solar time) were taken. Next for the M tides twenty-four averages were taken of heights grouped similarly according

* The true mean level for the year 1864 has been found to be 10·192 above this datum line, or ·192 of a foot higher than was supposed.

to the M hours. In thus averaging for the M tides every height which was recorded at a time within half an M hour before or after 0^h M time was taken as if it had been observed at 0^h M time, and so for 1^h, 2^h, 3^h, &c. of the M time. The correction on this was applied afterwards, as will be described later (§ 23). Four other averagings were performed according to the same rule for the K, L, N, O reckonings respectively; each averaging giving a group of twenty-four means.

18. The next step was to find for each of these six sets of averages the coefficients A_0, A_1, B_1, A_2, B_2, &c. of the harmonic formulæ,

$$\begin{aligned} A_0 + A_1 \cos\ nt &+ B_1 \sin\ nt \\ + A_2 \cos 2nt &+ B_2 \sin 2nt \\ &\cdots\cdots \\ &\cdots\cdots \\ + A_8 \cos 8nt &+ B_8 \sin 8nt, \end{aligned}$$

n denoting, as in § 1, the rate of increase of the hour-angle for each case, for instance γ for the K tide, $\gamma - \sigma$ for the M tide, and so on. The condition to be fulfilled is that the values of this formula calculated for $t=0$, $t=1$ . . , $t=23$ may agree as nearly as possible, on the whole, with the twenty-four numbers of the group (the sum of the squares of the differences to be a minimum*). The tabular forms and rules given by Mr. Archibald Smith, and published by the Admiralty, to be used for the harmonic reduction of the deviation of ships' compasses, have been adopted *mutatis mutandis*, and have proved very convenient.

19. If, instead of including only seventeen coefficients, A_0, A_1, B_1, ... A_8, B_8, the calculation had been extended to A_{11}, B_{11}, A_{12}, so as to include in all twenty-four coefficients, the calculated values would necessarily have agreed with the twenty-four numbers given by observation. But there was no apparent probability that anything more than accidental irregularities and errors of observation could be represented by higher terms than A_8, B_8, and therefore these were the highest included. The following Table exhibits the results of this process. The columns headed "differences" preserve the residues, however, and may be referred to should further study of the subject indicate that useful results are to be derived from them. The greatest of them is ·037 of a foot, and the maxima in each column are only from $\frac{1}{80}$ to $\frac{1}{40}$ of a foot.

Values of A_1, A_2, &c., to first Approximation.

	S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
A_1	+0·0231	−0·2052	−0·0305	+0·0223	+0·0181	−0·2963
B_1	−0·0255	−0·0236	−0·0120	−0·0058	+0·0048	+0·0687
A_2	+1·5598	−0·4540	−0·2276	−4·3176	+0·8191	−0·0904
B_2	+0·9923	−0·0061	+0·2669	+4·5037	−0·7342	−0·0007
A_3	+0·0086	+0·0037	−0·0096	−0·0138	−0·0008	−0·0073
B_3	+0·0004	+0·0015	+0·0093	+0·0408	+0·0111	+0·0078
A_4	+0·0295	−0·0127	−0·0457	−0·5443	−0·0094	+0·0030
B_4	+0·0009	−0·0021	−0·0927	−0·0878	−0·0122	+0·0034
A_5	0·0000	−0·0051	−0·0023	+0·0032	−0·0013	+0·0022
B_5	+0·0029	+0·0072	+0·0046	+0·0019	+0·0052	−0·0074
A_6	+0·0017	−0·0008	−0·0050	−0·1132	−0·0287	−0·0062
B_6	+0·0068	+0·0027	−0·0079	−0·1114	−0·0024	+0·0040

* According to Laplace's method of "least squares."

Values of A_1, A_2, &c., to first Approximation (*continued*).

	S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
A_7	+0·0008	+0·0030	−0·0056	+0·0021	−0·0022	+0·0202
B_7	+0·0046	−0·0011	+0·0043	−0·0031	−0·0004	−0·0084
A_8	+0·0011	+0·0058	−0·0421	+0·0295	+0·0048	−0·0057
B_8	+0·0028	−0·0033	+0·0312	−0·0416	−0·0001	+0·0073
A_0	10·1988	10·1989	10·1843	10·1992	10·1853	10·1971

$(\gamma-\eta)$ Series.

Calculated. (1)	Observed. (2)	Difference. (1)−(2)
11·8234	11·8231	+0·0003
12·0992	12·0976	+0·0016
11·8255	11·8226	+0·0029
11·1414	11·1528	−0·0114
10·2454	10·2413	+0·0041
9·3442	9·3386	+0·0056
8·6403	8·6455	−0·0052
8·3404	8·3371	+0·0033
8·5202	8·5184	+0·0018
9·1488	9·1539	−0·0051
10·0677	10·0731	−0·0054
11·0364	11·0268	+0·0096
11·7584	11·7593	−0·0009
12·0408	12·0420	−0·0012
11·8133	11·8154	−0·0021
11·1660	11·1607	+0·0053
10·2798	10·2897	−0·0099
9·3918	9·3870	+0·0048
8·6955	8·6889	+0·0066
8·3844	8·3886	−0·0042
8·5682	8·5701	−0·0019
9·2166	9·2153	+0·0013
10·1327	10·1360	−0·0033
11·0908	11·0874	+0·0034

(γ) Series.

Calculated. (1)	Observed. (2)	Difference. (1)−(2)
9·5336	9·5384	−0·0048
9·5944	9·5886	+0·0058
9·7901	9·7940	−0·0039
10·0467	10·0470	−0·0003
10·2872	10·2825	+0·0047
10·5013	10·5077	−0·0064
10·6300	10·6250	+0·0050
10·6197	10·6209	−0·0012
10·5148	10·5167	−0·0019
10·3483	10·3443	+0·0040
10·1501	10·1538	−0·0037
10·0000	9·9977	+0·0023
9·9408	9·9431	−0·0023
9·9882	9·9840	+0·0042
10·1539	10·1621	+0·0082
10·3705	10·3586	+0·0119
10·5572	10·5702	−0·0130
10·6729	10·6626	+0·0103
10·6636	10·6673	−0·0037
10·5373	10·5408	−0·0035
10·3552	10·3461	+0·0091
10·1041	10·1140	−0·0099
9·8107	9·8042	+0·0065
9·6030	9·6034	−0·0004

$(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$ Series.

Calculated. (1)	Observed. (2)	Difference. (1)−(2)
9·8159	9·8165	−0·0006
10·0343	10·0483	−0·0140
10·2272	10·2018	+0·0254
10·4373	10·4650	−0·0277
10·6552	10·6342	+0·0210
10·5447	10·5549	−0·0102
10·3081	10·3057	+0·0024
10·1817	10·1864	−0·0047
9·9976	9·9850	+0·0126
9·9221	9·9460	−0·0239
10·0186	9·9894	+0·0292
9·9607	9·9846	−0·0239
9·9119	9·9033	+0·0086
10·0811	10·0704	+0·0107
10·2596	10·2839	−0·0243
10·4881	10·4609	+0·0272
10·6960	10·7134	−0·0174
10·5723	10·5700	+0·0023
10·3501	10·3393	+0·0108
10·2197	10·2332	−0·0135
9·9996	9·9912	+0·0084
9·9041	9·9010	+0·0031
9·9726	9·9838	−0·0112
9·8655	9·8549	+0·0106

$(\gamma-\sigma)$ Series.

Calculated. (1)	Observed. (2)	Difference. (1)−(2)
5·2674	5·2795	−0·0121
8·2397	8·2397	0·0000
12·3265	12·3143	+0·0122
15·4386	15·4591	−0·0205
16·4609	16·4382	+0·0227
15·8858	15·9041	−0·0183
14·0736	14·0634	+0·0102
11·3474	11·3496	−0·0022
8·5247	8·5289	−0·0042
6·1588	6·1519	+0·0069
4·5765	4·5841	−0·0076
4·1587	4·1516	+0·0071
5·2398	5·2461	−0·0063
8·1633	8·1588	+0·0045
12·2161	12·2178	−0·0017
15·3376	15·3410	−0·0034
16·4241	16·4160	+0·0081
15·9220	15·9342	−0·0122
14·1568	14·1451	+0·0117
11·4504	11·4566	−0·0062
8·5987	8·6019	−0·0032
6·1570	6·1441	+0·0129
4·5249	4·5446	−0·0197
4·1303	4·1112	+0·0191

$(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$ Series.			$(\gamma-2\sigma)$ Series.		
Calculated. (1)	Observed. (2)	Difference. (1)−(2)	Calculated. (1)	Observed. (2)	Difference. (1)−(2)
10·9849	10·9688	+0·0161	9·8166	9·8427	−0·0261
10·5382	10·5528	−0·0146	9·8354	9·8278	+0·0076
10·0146	10·0059	+0·0087	9·9348	9·9300	+0·0048
9·4882	9·4898	−0·0016	10·0573	10·0630	−0·0057
9·1314	9·1350	−0·0036	10·1567	10·1549	+0·0018
9·1141	9·1095	+0·0046	10·2547	10·2565	−0·0018
9·3896	9·3920	−0·0024	10·3529	10·3448	+0·0081
9·8195	9·8203	−0·0008	10·4185	10·4312	−0·0127
10·3658	10·3630	+0·0028	10·4357	10·4260	+0·0097
10·9264	10·9284	−0·0020	10·4499	10·4515	−0·0016
11·2698	11·2707	−0·0009	10·4696	10·4704	−0·0008
11·2642	11·2602	+0·0040	10·4270	10·4348	−0·0078
10·9573	10·9627	−0·0054	10·3790	10·3569	+0·0221
10·4766	10·4723	+0·0043	10·4114	10·4368	−0·0254
9·9446	9·9460	−0·0014	10·4014	10·3937	+0·0077
9·4472	9·4479	−0·0007	10·3101	10·2850	+0·0251
9·1166	9·1163	+0·0003	10·2987	10·3500	−0·0513
9·1059	9·1028	+0·0031	10·3189	10·2643	+0·0546
9·3910	9·3987	−0·0077	10·2291	10·2642	−0·0351
9·8357	9·8248	+0·0109	10·1271	10·1163	+0·0108
10·3834	10·3934	−0·0100	10·0589	10·0606	−0·0017
10·9362	10·9320	+0·0042	9·9363	9·9238	+0·0125
11·2746	11·2701	+0·0045	9·8322	9·8620	−0·0298
11·2714	11·2833	−0·0119	9·8190	9·7823	+0·0367

20. In the averages for any one of the S, K, L, M, N, O tides explained above, the influence of each of the others is nearly eliminated because of the greatness of the number of periods (roughly 360 and 720) of each in the series of observed heights included in the summations. The choice of the approximate period $369^d\ 3^h$, as explained above (§ 16), makes as little as possible of the mutual influence of the two largest tides, the lunar and solar semidiurnal tides, in the two averagings performed to determine these two tides. But the incommensurability of the periods renders it impossible to altogether escape, in the direct synthesis for any one tide, the influence of the others. Accordingly, the coefficients A_1, B_1, &c., shown above, are to be regarded as first approximations in the mathematical solution of the problem. The next step followed was to find corrections upon each summation for the influence of the tides determined by the other summations, these corrections, for a second approximation, being calculated on the supposition that the first approximate values of A_1, B_1, A_2, &c., already found, are correct. An auxiliary Table (see § 15, above) for performing this process has been formed, and must be printed with rules for its use along with the other Tables; and therefore it is sufficient at present to state the results for Ramsgate 1864. The corrections thus formed are to be subtracted from the values of A_1, A_2, &c., to first approximation, and are as follows:—

21. Table of Corrections of the 6×16 Coefficients A_1, B_1, &c.

	S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
A_1	−·0025	−·0002	−·0021	+·0087	−·0151	−·0032
B_1	+·0015	+·0001	−·0050	−·0003	+·0032	+·0056
A_2	−·0018	−·0313	+·0065	−·0009	+·0093	−·0188
B_2	−·0104	+·0105	−·0338	+·0033	+·0101	−·0008
A_3	+·0009	+·0087	−·0074	−·0025	−·0001	−·0063
B_3	−·0004	−·0074	+·0152	−·0015	+·0044	+·0032

Table of Corrections of the 6×16 Coefficients A_1, B_1, &c. (*continued*).

	S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
A_4	−·0005	+·0043	+·0067	−·0001	+·0015	−·0046
B_4	−·0013	+·0026	−·0041	−·0013	+·0016	−·0003
A_5	+·0105	−·0101	+·0037	+·0009	−·0052	+·0024
B_5	−·0184	+·0075	+·0020	−·0014	+·0088	−·0109
A_6	−·0198	+·0012	−·0011	−·0007	−·0004	−·0097
B_6	−·0042	+·0009	+·0017	+·0017	−·0020	−·0067
A_7	−·0030	+·0039	−·0145	−·0002	+·0021	+·0086
B_7	−·0035	+·0042	+·0014	−·0010	−·0031	−·0103
A_8	+·0002	−·0009	−·0431	+·0005	+·0008	+·0029
B_8	+·0001	+·0064	+·0362	−·0014	−·0010	−·0030

Values of A_1, A_2, &c., to second Approximation.

	S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
A_1	+0·0256	−0·2050	−0·0284	+0·0136	+0·0332	−0·2931
B_1	−0·0270	−0·0237	−0·0070	−0·0055	+0·0016	+0·0631
A_2	+1·5616	−0·4227	−0·2341	−4·3167	+0·8098	−0·0716
B_2	+1·0027	−0·0166	+0·3007	+4·5004	−0·7443	+0·0001
A_3	+0·0077	−0·0050	−0·0022	−0·0113	−0·0007	−0·0010
B_3	+0·0008	+0·0089	−0·0059	+0·0423	+0·0067	+0·0046
A_4	+0·0300	−0·0170	−0·0524	−0·5442	−0·0109	+0·0076
B_4	+0·0022	−0·0047	−0·0886	−0·0865	−0·0138	+0·0037
A_5	−0·0105	+0·0050	−0·0060	+0·0023	+0·0039	−0·0002
B_5	+0·0213	−0·0003	+0·0026	+0·0033	−0·0036	+0·0035
A_6	+0·0215	−0·0020	−0·0039	−0·1125	−0·0283	+0·0035
B_6	+0·0110	+0·0018	−0·0096	−0·1131	−0·0004	+0·0107
A_7	+0·0038	−0·0009	+0·0089	+0·0023	−0·0043	+0·0116
B_7	+0·0081	−0·0053	+0·0029	−0·0021	+0·0027	+0·0019
A_8	+0·0009	+0·0067	+0·0010	+0·0290	+0·0040	−0·0086
B_8	+0·0027	−0·0097	−0·0050	−0·0402	+0·0009	+0·0103
A_0	10·1988	10·1989	10·1843	10·1992	10·1853	10·1971

22. The values A_2, B_2 in columns S and M express the mean solar semidiurnal and mean lunar semidiurnal tides.

A_2, B_2 of column K express the lunar declinational semidiurnal tide.

A_2, B_2 of columns L and N express two constituents of the lunar elliptic semidiurnal tide.

A_2, B_2 of column O express zero tolerably well*.

A_1, B_1 of columns K and O express the two constituents of the lunar diurnal tide.

A_1, B_1 of column S express one constituent of the solar elliptic diurnal tide.

A_1, B_1 of column M express one constituent of the lunar elliptic diurnal tide†.

A_1, B_1 of columns L and N possibly depend on the elliptic lunar diurnal tides, but will no doubt be found a better approximation to zero when

* There being no theoretical tide of the period corresponding to them.

† Being the resultant of the two corresponding angular velocities $\gamma-\sigma+\varpi$ and $\gamma-\sigma-\varpi$, inasmuch as for a single year the effect of the $\pm\varpi$ may be neglected.

calculated by the average of several years. There is no tide corresponding strictly to them.

A_3, B_3 are, as they ought to be, very good approximations to zero in all the columns except M. Their values in this column constitute, probably, a genuine expression of the ter-diurnal lunar tide [not included in the preceding general schedule (§ 2) but referred to in § 3], investigated by Laplace as depending on the fourth power of the moon's parallax.

A_4, B_4 express shallow-water tides* derived from the *lunar* semidiurnal tide, according to precisely the same dynamical principle as that by which Helmholtz has explained the over-tones generated in very loud sounds, even when the source of the sound is a simple harmonic motion. There ought to be no sensible tide expressed by A_4 and B_4 in column L, and the comparative largeness of these numbers is probably an accident, owing either to errors of observation or the imperfection of the system of combination adopted, or a chance concurrence of disturbance due to wind &c.

A_5, B_5 in almost every column approximate remarkably well to zero; and even their greatest values (those of column S) express merely a deviation of $\frac{1}{40}$ of a foot (or 0·3 of an inch) on each side of the mean level.

A_6, B_6 may be considered as insensible for every column except M, for which they express, as they ought to do, an undoubtedly genuine shallow water tide, being the second harmonic (as it were overtone) of the lunar semidiurnal tide.

A_7, B_7 are very good approximations to zero in all the columns.

A_8, B_8 in column M express probably a genuine, though very small, shallow-water tide, the third harmonic of the lunar semidiurnal tide. There is a very good approximation to zero in all of the other columns.

23. It is interesting, with reference to the mode of reduction which has been adopted, to remark to how nearly zero the comparatively large values of A_7, B_7 in column O, and A_8, B_8 in column L of the first approximation are reduced by the corrections found in the second approximation, explained above. Selecting from the preceding Table the coefficients which are each probably a genuine tide, and applying the proper correction (Everett, Roy. Soc. Edin. Trans. 1860) to take account of the circumstance that the mean height for each hour has been virtually taken for the height at the middle of the hour, we have the following, according to notation of § 2.

	S	K	L	M	N	O
	$(\gamma-\eta)$	(γ)	$(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	$(\gamma-\sigma)$	$(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	$(\gamma-2\sigma)$
R_1	0·0373	0·2070	....	0·0145	....	0·3008
ϵ_1	313° 28′·9	186° 36′·2	....	337° 58′·9	....	167° 51′·0
R_2	1·8772	0·4279	0·3856	6·3078	1·1126	....
ϵ_2	32° 42′·2	182° 14′·9	127° 53′·7	133° 48′·4	317° 24′·6	....
R_3	....	....	....	0·0448	....	....
ϵ_3	....	....	....	104° 57′·4	....	....
R_4	0·0315	....	0·1078	0·5771	....	....
ϵ_4	4° 11′·4	....	239° 24′·7	189° 1′·9	....	....
R_6	0·0268	....	....	0·1771	....	....
ϵ_6	27° 2′·5	....	....	225° 8′·3	....	....
R_8	....	....	....	0·0599	....	....
ϵ_8	....	....	....	305° 51′·3	....	....

* It is this term that makes the whole resultant tide rise faster than it falls, as is generally observed in estuaries, and other localities separated from the oceans by considerable spaces of shallow water.

24. The shallow-water tides referred to above depend on the rise and fall of the tide, amounting to some sensible part of the whole depth of the water, or, which comes to the same, the horizontal velocity of the water being sensible in comparison with the velocity of propagation of a long wave, through some considerable portion of the sea which sensibly influences the tides at the point of observation. Helmholtz's explanation of compound sounds, according to which two sounds, each a simple harmonic, having mt, nt for their arguments, give rise, if loud enough, to sounds having for their arguments $(m+n)t$, $(m-n)t$, suggest that the compound action of the solar and lunar semidiurnal tides, must give rise to shallow-water tides whose arguments are $2(\sigma-\eta)t$ and $2(2\gamma-\eta-\sigma)t$. It is intended with the least possible delay to perform averagings with a view to determine these tides*. The great influence of the British Channel, and the large extent of it through which the shallow-water condition specified above is fulfilled, makes it probable that the new tidal constituents now anticipated will be found sensible.

25. The step next undertaken has been to find mean solar daily averages, and to purify these of lunar-diurnal and semidiurnal influence; and in a few days more I hope to determine the lunar fortnightly declinational and the solar semiannual tides; also the annual variation indicated by Mr. Ebenezer Maclean's calculations (§ 10), and of the $2(\sigma-\eta)$ luni-solar fortnightly shallow-water tide suggested (§ 24) by Helmholtz's theory of compound sounds. This work is now in progress†.

26. Observations made every quarter hour during several periods within four days at a station in the Fiji Islands, supplied to me through the kindness of Lieut. Hope, R.N., have been partially reduced, by a rigorous application of the method of least squares. This somewhat laborious process has been undertaken not only for the sake of the results to be obtained, which, considering the chaotic mass of statements constituting our present information regarding tides in the Pacific, we may regard as not without value in themselves, but also to show how much may be done by applying the harmonic analysis to a very short series of observations such as may be made in the course of a few days in any part of the world by surveying officers. I expect to be able in the present case to obtain somewhat accurate determinations of the mean lunar semidiurnal, the mean solar semidiurnal, the lunar diurnal, and the solar diurnal tides, each of which is probably sensible in the series of observed heights which have been supplied; but it has been necessary to defer this work to allow the full reduction of the Ramsgate 1864 series to be pushed on as far as possible towards completion before the present Meeting of the British Association.

27. The work requisite to obtain the results stated above has been, as may readily be conceived, very heavy; but a large part of it is available for other years and other places. It has been almost all performed by Mr. E. Roberts, who has devoted himself to it with most satisfactory zeal, ability, and perseverance, in intervals of his laborious duties for the Nautical

* [Note added Dec. 1868.] This has now been done by Mr. Roberts for the $2(\sigma-\eta)$ (or synodic fortnightly) tide, and a very notable result has been obtained (see § 28 below); but as yet I cannot feel much confidence in it, because the period is that of the spring to neap and back to spring tides, and the Ramsgate instrument did not work well through the longer ranges (the buoy, for instance, sometimes rested on the bottom, and the failing curve-register was supplied by guess). The calculation *necessarily* includes instrumental errors depending on the gauge not working equally well through long and short ranges.

† Mr. Roberts has since completed it. For results see § 28 below. [Note added Dec. 1868.]

Almanac Office. It is to be hoped that arrangements may be made to allow him to give his whole time to a continuance of the work during the ensuing year, with assistant calculators working by aid of printed tables according to methods which by the experience now gained may be put into the form of convenient practical rules. Thus, while Mr. Roberts may work out proper methods for short or irregular series of observations, others may be employed to deduce results from tide-gauge diagrams of other British ports, and from the admirable series of recorded heights (every quarter hour) for Brest and other French ports which have been shown to me in the Hydrographic Office in Paris through the kindness of MM. Liouville and Delaunay, and Admiral Paris, and which may be had, it is hoped, on application by the Committee.

[Conclusion of Report up to Aug. 19, 1868.]

Supplementary Report by Mr. Roberts.

28. In the determination of the lunar monthly and solar annual (elliptic) tides, the lunar fortnightly and solar semiannual (declinational) tides alluded to above (§ 25), and the luni-solar fortnightly shallow-water (synodic) tide (§ 24), let h be the height above the mean of the solar daily averages purified of lunar-diurnal and semidiurnal influence, then

$$
\begin{array}{ll}
h=+A\cos\sigma t & +B\sin\sigma t \\
\quad +C\cos 2\sigma t & +D\sin 2\sigma t \\
\quad +C'\cos 2(\sigma-\eta)t & +D'\sin 2(\sigma-\eta)t \\
\quad +E\cos\eta t & +F\sin\eta t \\
\quad +G\cos 2\eta t & +H\sin 2\eta t
\end{array}
$$

Multiplying the value of h for each day by the respective values of $\cos\sigma t$, $\sin\sigma t$, $\cos 2\sigma t$, $\sin 2\sigma t$, &c., calculated from 1864, Jan. $8^{d}\,11^{h}\,30^{m}$ as era of reckoning, for which $t=0$, and adding, we form the following equations:—

$$
\begin{array}{rcrrrrrr}
\text{feet.} & & & & & & & \\
+1\cdot70 & = & +181\cdot75A & +1\cdot52B & +2\cdot44C & +3\cdot31D & +2\cdot75C' & +3\cdot96D' \\
 & & & & +4\cdot18E & -0\cdot54F & +4\cdot24G & -1\cdot11H \\
+5\cdot58 & = & +1\cdot52A & +183\cdot25B & -3\cdot38C & +1\cdot73D & -4\cdot02C' & +1\cdot99D' \\
 & & & & +6\cdot73E & +0\cdot25F & +6\cdot86G & +0\cdot50H \\
+3\cdot17 & = & +2\cdot44A & -3\cdot38B & +183\cdot17C & +0\cdot88D & +0\cdot65C' & +0\cdot92D' \\
 & & & & -1\cdot50E & -0\cdot10F & -1\cdot51G & -0\cdot19H \\
+5\cdot07 & = & +3\cdot31A & +1\cdot73B & +0\cdot88C & +181\cdot83D & +0\cdot92C' & -0\cdot72D' \\
 & & & & +3\cdot05E & -0\cdot08F & +3\cdot06G & -0\cdot17H \\
-15\cdot02 & = & +2\cdot75A & -4\cdot02B & +0\cdot65C & +0\cdot92D & +183\cdot19C' & +0\cdot97D' \\
 & & & & -1\cdot68E & -0\cdot11F & -1\cdot70G & -0\cdot22H \\
-9\cdot24 & = & +3\cdot96A & +1\cdot99B & +0\cdot92C & -0\cdot72D & +0\cdot97C' & +181\cdot81D' \\
 & & & & +3\cdot25E & -0\cdot10F & +3\cdot26G & -0\cdot20H \\
-6\cdot41 & = & +4\cdot18A & +6\cdot73B & -1\cdot50C & +3\cdot05D & -1\cdot68C' & +3\cdot25D' \\
 & & & & +182\cdot43E & +0\cdot00F & -0\cdot14G & +0\cdot00H \\
-22\cdot18 & = & -0\cdot54A & +0\cdot25B & -0\cdot10C & -0\cdot08D & -0\cdot11C' & -0\cdot10D' \\
 & & & & +0\cdot00E & +182\cdot57F & -0\cdot00G & -0\cdot00H \\
+4\cdot39 & = & +4\cdot24A & +6\cdot86B & -1\cdot51C & +3\cdot06D & -1\cdot70C' & +3\cdot26D' \\
 & & & & -0\cdot14E & -0\cdot00F & +182\cdot43G & +0\cdot00H \\
+13\cdot04 & = & -1\cdot11A & +0\cdot50B & -0\cdot19C & -0\cdot17D & -0\cdot22C' & -0\cdot20D' \\
 & & & & +0\cdot00E & -0\cdot00F & +0\cdot00G & +182\cdot57H
\end{array}
$$

These equations, solved by successive approximations, give the following values of the coefficients:—

feet.

$A=+0{\cdot}0109$, $B=+0{\cdot}0296$ } the coefficients for the lunar monthly tide (elliptic).

$R=0{\cdot}0316$ $\epsilon=69^\circ\,47'$ (5·30 mean solar days).

$C=+0{\cdot}0181$, $D=+0{\cdot}0277$ } the coefficients for the lunar fortnightly tide (declinational).

$R=0{\cdot}0331$ $\epsilon=56^\circ\,50'$ (2·16 mean solar days).

$C'=-0{\cdot}0815$, $D'=-0{\cdot}0508$ } the coefficients for the luni-solar fortnightly shallow-water tide (synodic).

$R=0{\cdot}0960$ $\epsilon=211^\circ\,56'$ (8·69 mean solar days).

$E=-0{\cdot}0367$, $F=-0{\cdot}1216$ } the coefficients for the solar annual tide (elliptic and meteorological).

$R=0{\cdot}1270$ $\epsilon=253^\circ\,12'$ (256·89 mean solar days).

$G=+0{\cdot}0225$, $H=+0{\cdot}0713$ } the coefficients for the solar semiannual tide (declinational and meteorological?).

$R=0{\cdot}0748$ $\epsilon=72^\circ\,29'$ (36·77 mean solar days).

29. The following Tables exhibit the comparative times of maximum of each of the preceding tides, and the times of maximum attraction to which each, if genuine and astronomical, is due.

Lunar monthly tide.

Maximum height (calculation).	d	h	Moon in apogee.	d	h
1864. Jan.	13	19	1863. Dec.	28	3
Feb.	10	2	1864. Jan.	24	9
Mar.	8	10	Feb.	20	9
April	4	18	Mar.	18	20
May	2	1	April	15	14
	29	9	May	13	9
June	25	17	June	10	3
July	23	1	July	7	20
Aug.	19	8	Aug.	4	8
Sept.	15	16		31	12
Oct.	13	0	Sept.	27	17
Nov.	9	8	Oct.	25	6
Dec.	6	15	Nov.	22	1
1865. Jan.	2	23	Dec.	19	21

Solar annual tide.

Maximum height (calculation).	d	Sun in apogee.	d
1864. Sept.	21	1864. July	2

Solar semiannual tide.

Maximum height (calculation).	d	Sun at maximum declination, North and South (N. & S.).	d	
1864. Feb.	14	1863. Dec.	22	S.
Aug.	15	1864. June	21	N.

Lunar fortnightly tide.

Maximum height (calculation). 1864.	d	h	Moon at maximum declination, North and South (N. & S.). 1864.	d	h		°	′
Jan.	10	15	Jan.	6	20	S.	21	3
	24	7		19	17	N.	21	0
Feb.	6	23	Feb.	3	7	S.	20	53
	20	15		16	0	N.	20	48
Mar.	5	7	Mar.	1	16	S.	20	38
	18	23		14	7	N.	20	32
April	1	14		28	21	S.	20	25
	15	6	April	10	16	N.	20	22
	28	22		25	3	S.	20	19
May	12	14	May	8	1	N.	20	19
	26	6		22	10	S.	20	20
June	8	22	June	4	10	N.	20	21
	22	14		18	19	S.	20	20
July	6	5	July	1	17	N.	20	20
July	19	21	July	16	6	S.	20	16
Aug.	2	13		29	0	N.	20	12
	16	5	Aug.	12	17	S.	20	4
	29	21		25	6	N.	19	59
Sept.	12	13	Sept.	9	1	S.	19	50
	26	5		21	13	N.	19	46
Oct.	9	20	Oct.	6	7	S.	19	40
	23	12		18	22	N.	19	39
Nov.	6	4	Nov.	2	12	S.	19	38
	19	20		15	8	N.	19	39
Dec.	3	12		29	19	S.	19	40
	17	4	Dec.	12	18	N.	19	41
	30	20		27	5	S.	19	40

Synodic fortnightly tide.

Maximum height (calculation). 1864. d h	Moon's phase, New and Full (N. & F.). 1864. d h	Maximum height (calculation). 1864. d h	Moon's phase, New and Full (N. & F.). 1864. d h
Jan. 17 4	Jan. 8 20 N.	July 27 3	July 18 19 F.
31 22	23 10 F.	Aug. 10 21	Aug. 2 3 N.
Feb. 15 17	Feb. 7 6 N.	25 16	17 2 F.
Mar. 1 11	22 5 F.	Sept. 9 10	31 18 N.
16 6	Mar. 7 16 N.	24 4	Sept. 15 9 F.
31 0	22 22 F.	Oct. 8 23	30 11 N.
April 14 18	April 6 2 N.	23 17	Oct. 14 18 F.
29 13	21 13 F.	Nov. 7 11	30 3 N.
May 14 7	May 5 12 N.	22 6	Nov. 13 6 F.
29 1	21 1 F.	Dec. 7 0	28 19 N.
June 12 20	June 4 0 N.	21 19	Dec. 12 19 F.
27 14	19 11 F.	1865.	
July 12 9	July 3 12 N.	Jan. 5 13	28 9 N.

30. For the sake of comparison between the calculated heights and the heights given by the diagram sheets, one day has been selected at random, and the heights computed from the results obtained, neglecting all tides whose maximum effect did not exceed 1 inch (·083 of a foot). The following are the results:—

1864.	h	Calculated heights. C ft.	Heights from diagram. O ft.	Difference. C−O ft.	1864.	h	Calculated heights. C ft.	Heights from diagram. O ft.	Difference. C−O ft.
Aug. 18	0	19·06	19·05	+0·01	Aug. 18	12	18·95	18·7	+0·25
	1	17·96	17·65	+0·31		13	18·69	18·55	+0·14
	2	15·04	14·6	+0·44		14	16·58	16·65	−0·07
	3	11·10	10·9	+0·20		15	13·00	13·1	−0·10
	4	6·93	7·3	−0·37		16	8·86	9·55	−0·69
	5	3·63	4·45	−0·82		17	5·18	6·05	−0·87
	6	1·65	2·4	−0·75		18	2·84	3·6	−0·76
	7	1·25	1·5	−0·25		19	1·90	2·45	−0·55
	8	3·09	2·45	+0·64		20	2·96	2·9	+0·06
	9	7·28	6·15	+1·13		21	6·40	5·65	+0·75
	10	12·58	12·1	+0·48		22	11·41	10·45	+0·96
	11	16·92	17·6	−0·68		23	16·38	16·95	−0·57

It will be noticed that the largest differences are about the times of half-tide, and which can be accounted for by the diagram sheets not answering to the times as shown by the clock, a discrepancy of only five minutes (a very probable amount for the Ramsgate diagrams) causing at these times a difference in heights of 6 inches. The barometer has probably been higher than the average on the day selected.

31. A series of tide-records, taken near the entrance of the George's Docks, Liverpool, has been supplied, on application, by the kindness of the Board of the Mersey Dock Estate. The heights through about twelve hours each, during three interruptions in the tide curve (caused by the accidental stopping of the clock), have been inferred from the tide-diagrams of the self-registering tide-gauge at Helbre Island at the mouth of the Dee. This series promises to give as good determinations as can probably be obtained from the diagrams of a self-registering tide-gauge, the sheets having apparently been most carefully stretched round the drum, and the apparatus watched from time to time.

32. The diagram sheets are divided into quarter hours and quarter feet, and the heights have been read off for each quarter hour, although in the reductions at present in hand the height at each integral mean solar hour has

alone been used, tables similar to those described above (§ 14) not having at present been adapted to quarter-hour observations.

33. The periods chosen are the same length as those used in the Ramsgate series, and the observations have been dealt with in every way similarly to those of Ramsgate already described. The observations extend from September 1857 to September 1858. The datum-line is 12 feet below the level of the sill of George's Dock.

34. The following are the values of A_1, B_1, &c. for Liverpool to first approximation, to which point the analysis has at this time been completed:—

	S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
A_1	+0·0198	−0·1806	−0·0134	−0·0222	−0·0065	+0·1061
B_1	+0·0463	+0·3380	+0·0186	−0·0237	−0·0488	−0·4206
A_2	+3·1645	+0·8899	+0·3639	−6·1277	−0·6508	+0·2528
B_2	+0·6825	+0·7690	−0·4247	+7·3394	+1·7183	+0·1766
A_3	+0·0062	+0·0164	−0·0111	+0·0773	−0·0095	+0·0084
B_3	+0·0304	+0·0123	−0·0148	+0·0607	+0·0199	+0·0294
A_4	+0·0515	+0·0130	+0·0189	−0·6502	−0·0500	−0·0095
B_4	−0·0400	+0·0199	+0·0980	−0·0866	+0·0342	+0·0115
A_5	−0·0045	+0·0033	+0·0188	+0·0141	+0·0015	−0·0115
B_5	+0·0085	−0·0014	+0·0150	+0·0120	+0·0128	−0·0073
A_6	−0·0090	−0·0048	+0·0048	−0·0784	+0·0036	−0·0227
B_6	−0·0066	+0·0054	+0·0126	+0·1497	+0·0075	−0·0190
A_7	−0·0022	−0·0006	−0·0047	+0·0172	+0·0085	+0·0134
B_7	−0·0027	−0·0058	+0·0016	−0·0004	−0·0207	−0·0175
A_8	+0·0002	−0·0045	−0·0778	−0·0503	+0·0113	−0·0122
B_8	−0·0059	−0·0031	+0·0607	−0·0142	+0·0135	+0·0169
A_0	16·7192	16·7129	16·7189	16·7215	16·7198	16·7072

Series calculated with these terms agree closely with the original sets of means, the greatest difference being only 0·073 of a foot.

35. Professor Fuller having applied to W. Parkes, Esq., M. Inst. C.E., for a set of tide observations of any port in India, that gentleman has kindly placed at the disposal of the Committee, for analysis, a series of personal tide observations taken at Bombay from January 29, 1867 to June 4, 1867. The heights were observed at successive intervals of ten minutes, and were taken under the superintendence of Mr. Ormiston, C.E. A few breaks of short duration in the observations have been supplied from a curve plotted for each day of interrupted observation. The datum-line is 72 feet below the level of the Town Hall datum.

36. The observations were not used as they were given, but heights for each quarter hour, the heights for the fifteen and forty-five minutes past each hour being interpolated. Tables similar to those previously described (§ 14), but adapted for the reduction of observations taken for every quarter hour, have been made for a period of 127 days. It is intended to extend these Tables to the same length as those adapted for the hourly observations, by the use of which it is expected that a much less laborious process will suffice for correcting the first approximations of A_1, B_1, &c. than that by the use of the second set of Tables (§ 15). (The observations of Liverpool may hereafter be reduced by the aid of these proposed quarter-hour Tables should it appear probable that better results than those now being obtained from the hourly observations may be expected.)

37. The following are the values of A_1, B_1, &c. for Bombay to first approximations, to which point the analysis has at this time been completed:—

	S $(\gamma-\eta)$	K (γ)	L $(\gamma-\frac{1}{2}\sigma-\frac{1}{2}\varpi)$	M $(\gamma-\sigma)$	N $(\gamma-\frac{3}{2}\sigma+\frac{1}{2}\varpi)$	O $(\gamma-2\sigma)$
A_1	−0·4488	−1·0522	+0·0168	+0·0713	−0·0380	+0·0777
B_1	+0·6221	−0·4854	−0·2350	−0·0782	−0·0412	−0·5523
A_2	+1·8245	−0·8071	−0·2669	+4·3095	+0·7291	−0·0011
B_2	+0·1475	+0·3340	−0·1679	−0·2053	+0·6429	+0·1524
A_3	−0·0059	−0·0270	+0·0172	−0·0475	+0·0132	+0·0143
B_3	−0·0079	+0·0113	+0·0024	−0·0664	+0·0081	+0·0185
A_4	+0·0056	+0·0075	−0·0366	+0·1008	+0·0064	0·0000
B_4	−0·0215	+0·0061	−0·0284	+0·0112	+0·0026	−0·0042
A_5	+0·0067	−0·0048	+0·0003	+0·0003	−0·0029	+0·0061
B_5	−0·0096	−0·0066	−0·0108	−0·0102	+0·0123	−0·0034
A_6	+0·0045	−0·0051	+0·0111	+0·0019	−0·0029	−0·0031
B_6	+0·0006	−0·0017	+0·0070	−0·0234	+0·0093	−0·0041
A_7	−0·0005	−0·0026	−0·0108	+0·0049	+0·0021	−0·0061
B_7	−0·0041	−0·0005	+0·0041	+0·0060	+0·0050	+0·0054
A_8	−0·0036	+0·0013	+0·0078	−0·0013	+0·0048	−0·0036
B_8	−0·0010	−0·0001	+0·0002	−0·0013	+0·0018	+0·0029
A_0	8·2004	8·2017	8·2015	8·2054	8·2010	8·1970

The series computed from these terms agree to a remarkable extent with the series from which they were deduced.

38. The observations taken at Ngaloa, in the Fiji Islands, mentioned at § 26, have not at present been completely reduced, the computations being still in the same state as at the date of the Meeting of the British Association, but will again be shortly taken up.

39. Before closing this Report it may not perhaps be inappropriate to refer to a few among the innumerable benefits that may be anticipated from a better knowledge of the laws of the tides. Among the scientific results which are likely to be deduced from the foregoing system of analysis of tide-observations, are an evaluation of the mass of the moon, definite information regarding the rigidity of the earth, an approximation to the depth of the sea from the observed velocities of tide-waves, and the retardation of the earth's rotation due to tidal friction. Physical geography will probably gain some knowledge as to the amount of water-surface in the hitherto unexplored districts of the Arctic and Antarctic regions, and more reliable information with respect to the origin, direction, and progress of tide-currents over the surface of the oceans. The effect of atmospheric pressure will be estimated, and also an approximation due to the effect of wind on the height of the tide from the simultaneously observed direction and force of the wind at different ports.

And the practical benefits to be derived from an accurate knowledge of the height of the tide at any time are certainly very great. Among them may be mentioned the navigation of large ships over shoals and bars, the docking, undocking, launching, and hauling up of vessels, and the floating off of stranded ships, and the working of small craft,—all operations in preparing for which a more or less exact foreknowledge of the tidal movements is required. The preservation of property, and the protection of unfinished works from the overflowing of rivers at very high tides, and engineering works carried on between high and low water, may be powerfully aided.

From tide-observations made at considerable intervals, and reduced in the manner followed above, some approximation to the secular changes (caused by the widening or narrowing, the deepening or filling up of rivers) can to some extent be estimated, and embankments or other protections carried out at those places where the tide is making encroachments, and a surer foundation afforded for the reclamation of land.

There can be no doubt that in all these operations every advance towards more perfect knowledge of the tidal movements will be accompanied by an economy of time and labour which in the aggregate must be very considerable.

40. It may here be mentioned that there now appears to be a considerable difference in the spring-range of the tide in the Thames at the London Docks (amounting to 13 inches in twenty-five years), caused, it is supposed, by the removal of obstructions, extensive dredging, and the construction of the embankment. In the Admiralty Tide-tables the heights of high water have been augmented by the apportioned amount, but *no correction* has been applied to the times of high water, which are also probably different.

It is to be hoped that the Lords Commissioners of the Admiralty may be pleased to direct that new determinations of the tides in the Thames and other places be made with a view of obtaining the requisite foundation for more extensive tide-tables than those now published, and supplying to the mariner more accurate and complete knowledge of the tides along our coasts.

Report of the Committee for the purpose of investigating the rate of Increase of Underground Temperature downwards in various Localities, of Dry Land and under Water. Drawn up by Professor EVERETT, *at the request of the Committee, consisting of* Sir WILLIAM THOMSON, *LL.D., F.R.S.*, Mr. E. W. BINNEY, *F.R.S., F.G.S.*, Principal FORBES, *LL.D., F.R.S.*, Mr. ARCHIBALD GEIKIE, *F.R.S., F.G.S.*, Mr. JAMES GLAISHER, *F.R.S.*, Rev. Dr. GRAHAM, Mr. FLEEMING JENKIN, *C.E., F.R.S.*, Sir CHARLES LYELL, *Bart., LL.D., F.R.S.*, Mr. J. CLERK MAXWELL, Mr. GEORGE MAW, *F.L.S., F.G.S.*, Prof. PHILLIPS, *LL.D., F.R.S.*, Mr. PENGELLY, *F.R.S., F.G.S.*, Professor RAMSAY, *F.R.S., F.G.S.*, Mr. BALFOUR STEWART, *LL.D., F.R.S.*, Mr. G. J. SYMONS, Professor JAMES THOMSON, *C.E.*, Professor YOUNG, *M.D., F.R.S.E., and* Professor EVERETT, *D.C.L., F.R.S.E., Secretary.*

THE following Circular, issued to the Committee in November 1867, explains the plan of procedure proposed, and the progress made in the investigation up to that time:—

SIR,—No Meeting of the Committee has yet been held; and as the Members are scattered over the country, it appears undesirable to wait for a Meeting. I therefore take this opportunity of laying before you the suggestions of Sir W. Thomson and myself with regard to the system of observation which should be adopted, and shall be glad to receive any suggestions of your own in reply.

The object of investigation is the rate at which, in various localities, the temperature of the earth increases in going downwards, at depths sufficiently great to render the annual range of temperature insensible.

The annual range of temperature diminishes in the ratio of 2 or 3 to 1 for every 10 feet of descent, and becomes reduced to a tenth of a degree Fahr. at depths of from 50 to 80 feet in this climate,—these results being derived from observations extending to 25 feet of depth, made at Greenwich and at three localities in Edinburgh.

A great boring or excavation, such as a mine, necessarily produces much disturbance of the normal temperature in its neighbourhood, and therefore, while observations in mines ought not to be neglected, we think the efforts of the Committee should be chiefly directed towards finding the temperatures at various depths in smaller borings, such as are usually made preliminary to mining-operations. As these are often carried to depths of from 300 to 600 feet, they will furnish very measurable differences of temperature at different depths in the same boring. It is suggested that observations should be made at every 50th foot of depth.

A method which has been used by Ångström will probably be found most convenient. It consists in enclosing a thermometer in a large glass bottle of water, letting it down to the point where the temperature is to be taken, leaving it in that position long enough to ensure that its temperature shall not differ sensibly from that of the soil nearest to it, then drawing it quickly up and reading off the thermometer before time is allowed for any sensible variation in its temperature. It would probably be found advisable to use two pistons or plugs (two bags of sand might answer the purpose), one above and the other below the bottle, to check currents of air or of water.

The thermoelectric method might also be followed with great advantage. Two wires, one of iron and the other of copper, insulated by gutta percha or some other covering as in submarine cables, and connected at their ends, might be let down, so as to bring their lower junction to the point where the temperature is to be taken, their upper junction being immersed in a basin of water, and the circuit completed through a galvanometer. The temperature of the water in the basin might then be altered till the galvanometer gave zero indication. An extremely accurate determination of the temperature at various depths could in this way be obtained with great ease and expedition, when the apparatus had once been prepared; but the method by water-bottle, though requiring more time for the observations, will probably be in general preferred on account of its simplicity.

Currents of water in a boring will render it unsuitable for our purpose; but water free from currents will but little affect the accuracy of observation.

Every Member of the Committee is requested to find out borings, in his own neighbourhood or elsewhere, that would be suitable for the investigation, and also to state whether he could undertake to make the observations himself, the thermometers or other apparatus required being supplied by the Committee.

Sir Wm. Thomson has already ordered from Casella two thermometers suitable for the water-bottle method, and expects to have them almost immediately for trial; they are spirit thermometers, with Fahrenheit scales, and are to be accurate to a tenth of a degree.

Your reply at your earliest convenience, with any suggestions you may have to offer, will oblige

Your obedient Servant,

J. D. Everett,

Queen's College, Belfast, Nov. 16, 1867. *Secretary to the Committee.*

The only observations yet taken in answer to the above invitation were made near Glasgow by Sir W. Thomson, from whose recent paper on Geological Time (Trans. Geol. Soc. Glasgow, vol. iii. part 1) the following paragraph (§ 29) may now be quoted.

"All sound naturalists agree that we cannot derive accurate knowledge of underground temperature from mines. But every bore that is made for the purpose of testing minerals gives an opportunity of observation. If a bore is made, and is left for two or three days, it will take the temperature of the surrounding strata. Let down a thermometer into it, take proper means for ascertaining its indications, draw it up, and you have the measure of the temperature at each depth. There are most abundant opportunities for geothermic surveys in this locality, by the numerous bores made with a view to testing minerals, and which have been left, either for a time or permanently, without being made the centre of a shaft. Through the kindness of Mr. Campbell, of Blythswood, several bores in the neighbourhood of his house have been put at the disposal of the Committee of the British Association, to which I have referred. In one of these bores very accurate observations have been made, showing an increase of temperature downwards, but which is not exactly the same in all the strata, the difference being no doubt due to different thermal conductivities of their different substances. I need not specify minutely the numbers; but I may say, in a general way, that the average increase is almost exactly $\frac{1}{50}$ of a degree Fahrenheit per foot of descent; which agrees with the estimate generally admitted as a rough average for the rate of increase of underground temperature in other localities.

"Another bore has been put at the disposal of the Committee, and the investigation of it is to be commenced immediately, so that I hope in the course of a few days some accurate results will be got. It has been selected because the mining engineer states in his report that the coal has been very much burned or charred, showing the effect of heat; and it becomes an interesting question, Are there any remains of that heat that charred the coal in ancient times, or has it passed off so long ago that the strata are now not sensibly warmer on account of it?"

The following report of these observations has been sent by Sir W. Thomson to the Secretary of the Committee:—

The operations were commenced in December last, with a spirit thermometer by Casella, having a stem 14 in. long, divided to tenths of a degree, and ranging from 39° to 61° Fahr.; it has a bulb $3\frac{1}{2}$ in. long by 1 in. diameter, is enclosed in an outer tube, nearly filled with spirit, and hermetically sealed; a protecting case of strong tin covered the whole; and to this case a stout copper wire was attached for lowering it in the bore.

Before commencing the operations, the thermometer, thus mounted, was left in a vessel of water until the temperature remained unchanged; it was then plunged into another vessel whose temperature differed by about 10° Fahr. from the former, and an interval of more than a minute elapsed before any change of reading could be observed; it was also ascertained that it could be raised from a depth of 60 fathoms and a reading taken within this time. The following observations were then made at Blythswood, about five miles west of Glasgow, during December and January, in a bore (No. 1) 60 fathoms deep, and filled with water to a constant depth of about 2 fathoms from the surface:—

Depth.	Temperature.	Mean Temp.	Difference per foot.
347 ft.	53°·65		
”	53·70	53°·69	
”	53·72		0°·01979
300	52·77		
”	52·70	52·76	
”	52·80		0·01967
240	51·61	51·58	
”	51·56		0·01800
180	50·49	50·50	
”	50·50		
120	49·20		0·02133
”	49·25	49·22	
”	49·20		0·02117
60	47·95	47·95	
”	47·95		

In all the observations taken with this thermometer, it was allowed to remain a day or two at least at each depth before being raised.

The thermometer was next removed to a second bore, at a short distance from the former, which was originally 95 fathoms deep, but had become filled up with sediment 45 fathoms, leaving only 50 fathoms free. Observations were made from early in March till the middle of April; the results from the greatest depths were pretty constant, but towards the surface they varied from time to time, occasioned in all probability by a constant flow of surface-water into the pipe, which found an escape at some unknown depth. The weather was generally wet, and there was always more or less entering the pipe, affected by the temperature of the air.

It is considered that the thermometer acted very satisfactorily at the depths at which it was used; but it is doubtful if its indications could be relied on for considerably greater depths, on account of the time taken to wind it up; and the speed could not be safely increased, particularly if the bore has rough projections on its sides. An instance of this occurred in the middle of April. While raising the thermometer with considerable velocity, it stuck, and would neither move up nor down; it had to be left till means were got to detach it gently from the obstruction; and when brought to the surface, the upper part of its strong casing was half torn away, but the thermometer itself quite safe.

With the view of obviating this difficulty, and of observing more rapidly, trials were being made at bore No. 1 with a thermo-electric junction of insulated copper and iron wire, let down to various depths, and the other junction placed in a vessel of water, which was heated or cooled, till a galvanometer showed no current, when the temperature was taken. Small discrepancies existed between the results thus obtained and those previously got directly with the thermometer; but there has not been time hitherto to ascertain their cause. The chief difficulties to be overcome were the want of a steady stand for the galvanometer (one of Sir Wm. Thomson's delicate mirror galvanometers), and the means of obtaining sufficient darkness to be able to read it.

A third method has been tried, which promises to give satisfactory results. Two of Phillips's maximum thermometers were furnished by Casella; but unfortunately on the second day of trial they met with an accident, and had to be returned to London to be repaired, and have only just now been re-

ceived. They will, it is expected, be tried soon at several bores in the neighbourhood of Glasgow, one of which is 174 fathoms deep, and at about half that depth passes through 18 fathoms of greenstone.

Several small hardy maximum thermometers, suited for rough work, are being constructed by Casella, and are to be had from him by any of the Members of Committee, or by parties recommended by them.

Members of Committee *are earnestly requested to cooperate energetically in the work*. The arrangements now made for the supply of suitable thermometers will allow useful results to be easily obtained in great abundance, from every variety of situation where available bores exist, at small expense, and without much expenditure of time.

Changes of the Moon's Surface. By Baron Von Mädler.

[A Communication ordered to be printed *in extenso*.]

The earliest idea of the heavenly bodies was that they were simply accessories of the earth, and existing only on her account. The course of astronomical discovery compelled these notions to give place to another view, that these heavenly bodies were independent spheres; from this naturally sprang a desire to learn more of these distant worlds. This desire can be accomplished in part by means of the sight which the telescope gives of the surface of the heavenly bodies; and our own satellite in particular presents such a "wealth of objects" that the most diligent efforts of the observer of the present day will fall far short of the representation of them all; and much, very much, must remain for his successors to accomplish. But though Riccioli more than 200 years ago attached to his 'Grimaldi's Almanack' of the Moon the superscription 'Nec homines vivere, nec plantæ crescere possunt,' and all subsequent observers must agree with him, yet there were not a few who sought to maintain a contrary opinion. In short, inhabitants of the moon have been sought for—Selenites, as Helvetius first called them. Gruithuysen hoped to see them when they might happen to be passing in a great mass through some mountain defile (wood-roads was his own word); and if they themselves could not be perceived, he was reluctant to abandon the hope that at least their buildings and similar works might be observed. But it is superfluous to dwell on a subject which rests upon such chimerical notions. The changes which we meet with in the moon have been brought about by natural power far greater and more marked than all the artificial works we have been able to execute, and these changes are still working; and since it cannot be doubted that with our present instruments it would be possible to perceive from the moon events such as some volcanic eruptions, and the raising of a new island out of the depths of the sea, so may we take a hint to discover, if possible, such events in the moon, and to explain analogously anything seen or supposed to be seen there. First, let us consider the volcanoes of which Sir W. Herschel speaks. That renowned inquirer expresses himself with all possible caution; he plainly states that he makes use of the word only because there must be some term of designation, and that he aimed at nothing less than a definite explanation. Notwithstanding this caution, however, many authors have spoken of burning volcanoes in the moon as an undoubted fact, and with a reference to Herschel's remarks. Herschel was the only one at that time who possessed such resources, and it had long been usual to receive all his observations without the proof which no

one but himself was able to give. These volcanoes we now know were the strong shining Ring-mountains, Aristarchus, Copernicus, and Kepler, which he perceived on the dark part of the moon, and which every one who possesses a telescope of sufficient power may also see at the approach of every first quarter of the moon. They always appear the same, with the exception of the small variations caused by libration; and I have never missed them even in total eclipses, finding them even then bright and distinct enough to convince me by measurement that they were identical with those well-known Ring-mountains. This also would not have escaped the notice of Herschel, if the important and varied undertakings, of which he alone was capable, had left him time to attend more especially to the moon. Schröter, of Lilienthal, put forward to occupy the field left free by Herschel. With telescopes of dimensions little less than Herschel's, he observed zealously and attentively the surface of the moon, and his "Selenotopographical fragments" for a long time excited general attention, though they are now almost forgotten; in fact, it cannot be denied that he mainly promoted the science by gaining Harding and Bessel to astronomical pursuits, and providing them with means to dedicate themselves entirely to its service; for his instruments, which for a long time had crowded up the Gottingen Observatory, have after a close examination by Gauss been pronounced almost useless, and the telescopic mirrors which were presented to the Cabinet des Physiques are all that now remain. The observations were never collected, neither were his data offered to others for the purpose of being reduced to mean librations; and besides, he paid too little attention to the advice of his renowned friend Olbers; he would discover variations on the moon's surface, without founding on them a moon map, for he expressly declared that he regarded them as useless. My endeavours to obtain from his sketches a connected picture of the moon, or at least of a part of it, were in vain; and Bessel has shown the inaccuracy of his measuring-apparatus by giving in one design of Schröter 42″ and in another 89″ for one and the same distance. Kunowsky has proved that all these variations which he pointed out were mere illusions. If we desire to arrive at unmistakeable conclusions respecting physical changes on the moon's surface, it is imperatively necessary to bear in mind the optical variations, which may consist

(1) In displacement by libration.
(2) In the different illumination by the sun.
(3) In the changeable transparency of our atmosphere.

(1) Mountains situated nearer the centre than the edge of the moon's disk in appearance are but little affected by libration; the nearer the edge the more they are affected. In such a position a crater might be easily concealed by one of its sides, so that one might suppose it only a mountain; whilst by a libration, which removes it further from the edge, this concealment does not take place, and we get a sight of the crater, *e.g.* that of Schröter's newly described crater in the Ring-mountain. Hevel is probably so to be explained.

(2) Mountain-walls throw shadows as long only as the angle of the inclination is greater than the height of the sun above their horizon; and moreover in places situated far from the centre of the moon, the shadow of a declivity is to our view concealed by the declivity itself; but the smaller mountains are only to be recognized by their shadows, and a whitish shadowless spot may always be circular and sharply defined without our being able to distinguish whether here a crater, a mountain, or neither is exhibited. Most of the moon-mountains demand of us repeated observations if we would gain a right judgment respecting them.

(3) Also, without either clouds or fog being distinctly observed, the transparency of our atmosphere is very different according to time and place, and little faint projecting forms may easily become alternately visible or invisible without adducing any other cause than the changeable diaphanism of our atmosphere. This alternation is most conspicuous in the so-called "rillen" (furrows), which, with few exceptions, are scarcely visible. I could point out many places which under the most favourable circumstance, of the air, appear streaked by numerous little rills, while at another time nothing, or nothing notable of them, is to be seen. An exception must be made only in the case of those which are so wide that we can perceive their shadows, as the rills near Huyghens and Aristarchus. Schmidt at Athens, who published a pamphlet exclusively on the rills of the moon's surface, has made the same remark. Again the green colour of some of the moon's landscapes is scarcely visible; it generally appears only when the moon is either quite or nearly full, therefore all the shadows are wanting. At that time, under favourable circumstances, the greatest part of the Mare Serenitatis appears of a uniform green colour, with a defined edge towards its blackish-grey margins. At other times these edges are observed, which are, however, but a lighter grey separated by a darker; but it is more difficult to distinguish clearly this green in Mare Crisium and Mare Humorum from the grey.

Hitherto telescopes of large dimensions have not been employed, or at least not continuously, for the moon, for which we can find sufficient reason. If gigantic instruments are to manifest their full power on these objects, not only occasionally, but in an unbroken succession of nights, it is a matter of necessity that they be not placed in Northern or Central Europe, and especially not in the lower regions of the atmosphere. Also they must admit of a lighter and speedier manipulation, that it may be possible to direct them to all parts of the celestial vault. For double stars and nebulous spots, it may suffice that the tube is movable only in or near the meridian; but this is by no means a sufficient condition for the moon, and we have never expected that Lord Rosse's telescope would advance our moon knowledge. It is not here exclusively the question, in the first instance, of the utmost magnifying power; but quite different, and more difficult conditions must be realized. We have learned, through the meritorious labours of Piazzi Smith, the unexpectedly great superiority which the Peak of Teneriffe offers to astronomical observations; and we can adduce the experiences of others, which unite in proving that the highest possible stations in a tropical, or at least subtropical country are to be fixed upon as the most fit for observations of extreme delicacy. In Italy, Dominique Cassini had seen spots on the disk of Venus; in Paris, though employing a more powerful instrument, he failed. I myself in Dorpat, and Lamont in Munich, have sought in vain for these spots which De Vico and Secchi found in Rome, and made use of for the determination of that planet's rotation. In South America, Humboldt could see stars in the Great Bear which in Europe he in vain sought, although the constellation has a much greater altitude. Neither would Lassell have changed his residence to Malta, had he not been aware of the great difference between the two climates: where the shadows of the trees can plainly be perceived by Venus's light, there also more can be attained for the moon than in our northern climate.

But in order to observe our satellite uninterruptedly and successfully, it must be possible to turn our instrument to every part of the heavens. We must be able to observe the first visible sickle in the W. or NW. after the new moon, and in the same manner the last in the E. A telescope which

does not admit of this easy change of position may serve for other astronomical purposes; for examinations of the moon's surface it is useless. For even the largest refractors means may be devised to effect this; but the great reflectors are mostly too unwieldly. Mechanics must contrive in this respect new means that the observer may be placed in a position to manage the great instrument in any direction that may be desired without extreme fatigue. For, besides that only under these circumstances all the moon's phases can be used, it is often necessary to keep an object in view for many successive hours, in order to catch all its peculiarities. But, lastly, the carrying out completely the representation of an extensive moon landscape, or even of the whole visible hemisphere, is so comprehensive a task that it cannot be expected from a single individual. W. Struvè, when he had set up the Dorpat refractor, thus expressed himself:—"He who would delineate the moon with this telescope, must relinquish every other astronomical work; for the details would be too many." And it must be taken into consideration that the mapping forms but a part of the labour here demanded, and that extended calculations of the most varied kind must be made before and during the mapping; and thus we arrive at the conclusion that the greatest labour of an individual cannot suffice, but many must participate in the work. If, however, anything is to be gained by such united observation, the globe of the moon must be arranged by degrees of latitude, for only in this manner would its every phase be used by all employed,—a long and troublesome method, so that it might appear to many that the results would not be worth the trouble; but if we wish to become fully acquainted with the natural proportions of our satellite, we have no other choice. What has lately been observed in the crater Linné proves at all events that *there* real changes have taken place, and *that* too under circumstances even visible to us. Since Linné (by my work commenced thirty-eight years since) formed a chief point in the trigonometrical chain, I was enabled to give the proportionately exact information, which was desired from me on different sides. The occurrence of perceptible changes is therefore for the first time proved; but equally remarkable is the circumstance that these events are rare; for in seven years' occupation with the moon's surface I never met with such before, neither have Lohrmann and other careful observers of that time.

Since, then, no doubt can be entertained that in such a case everything depends on being able to criticise how such an object appeared formerly, so might a possibly exhaustive representation and description of all the objects visible to us on the moon's surface be the fundamental conditions of further intellectual advance. Photography will be able in many respects to facilitate the labours of which we have above spoken; undoubtedly our incipient hopes went much further; but Uranology must rejoice in this new resource; nevertheless photographic representations of the moon cannot arrive at the details which an experienced eye and a large telescope can obtain; and in this case everything depends on the most exact representation of these delicate details. For the greater ring-mountains, plateaux, and chains of mountains belong to an epoch of formation very long past, and the present time does not dare to hope to perceive any changes in its general configuration; and yet an occurrence of which we are able to obtain knowledge is of the utmost importance. The crater Linné, which has hitherto offered the only authentic example of an admitted change, shows a diameter of 1·4 geographical miles, or six English miles; and it appears to us only under an angle of $5\frac{1}{2}$ seconds. We can hardly dare to expect still greater and more extensive occurrences, and a considerable time will elapse before one will be able to give a comparative

combination of these perceived relations. My eye, which has undergone an operation for cataract, will no longer permit me to make accurate and special continuous observations; yet on the 10th of May, 1867, I attempted an observation of the crater Linné in the heliometer of the Observatory at Bonn. I found it shaped exactly, and with the same throw of shadow, as I remember to have seen it in 1831. The event, of whatever nature it may have been, must have passed away without leaving any trace observable by me. I desire now to recommend to moon-observers a hitherto little considered subject, and one formerly very erroneously interpreted—the "straits" of light which only show themselves in high sun illumination; they make a show on Hevelius's map, and even much later, as Montes, Myconius, Eryx, Crates, Hercus, Sepher, and Seir, while still nothing is certain about them but that they are by no means elevations. Ridges of only 50 feet high are yet to be recognized through their shadow near the light edges, whilst these straits never show the smallest shadow, and vanish in the vicinity of the light edges. Their effect is that we perceive in the full moon but very little of what is seen in the quadratures, and especially near the light edges. Most probably it is only a very great capability of reflection of the ground by the high position of the sun and referrible to internal causes. They proceed in a radiating manner from single bright ring-mountains, especially from Tycho, Copernicus, Kepler, Byrgius, Aristarchus, and Olbers; from some other ring-mountains only single straits are proceeding on one side, as with Menelaus and Proclus. By a superficial observation they may easily be confounded with the mountain veins, and so much the more as these latter have often their origin at ring-mountains; but an attentive observer will easily remark essential differences between both appearances. I have endeavoured in my moon map to represent them; other observers (with the exception of those early ones who have explained them erroneously) have not come to my knowledge—I mean as to whether they have made research respecting changes which may occur in them. The easiest to observe is the light strait which divides the M. Serenitatis almost equally in halves; still there is another circumstance which recommends it to a closer inquiry, viz. because it is visible almost up to the light edge. I have sometimes still observed traces of the N.W. part of the strait when that of the S.E. was yet covered in night, since none of the other straits admitted so long a visibility; I have examined it several times for traces of shadow, but never perceived the smallest. Lastly, I would point out the rills of the moon's surface as objects whose visibility probably does not depend only on our atmosphere, but is to be referred to real changes; thus I have sought for two long years in vain for the S.W. continuation of the Ariadæus rill (though its existence came to my knowledge from other quarters) till it came unexpectedly to my view in 1833—certainly a most delicate object. It will always be advisable to observe on the same evening, not merely a single rill, but many somewhat similar ones; for, as the earth's atmosphere must exercise a like effect upon them all, so would a perceptible variation present us with a hint for further investigations.

Wishes and propositions, with the recollections of former years, are all which I am now able to offer. May they be an inducement to younger and more vigorous observers to draw new and fructifying facts to the light of our science! and may our satellite, after the monstrous fables which for almost the space of many thousand years have gained credence respecting it, now begin, not only by its course, but also by its natural constitution, to permit us to pierce deeper into the secrets of the fabric of the universe!

Report on Polyatomic Cyanides. *By* THOMAS FAIRLEY.

I. CYANOFORM.

I HAVE spent many months and much material in endeavours to obtain this body in a pure state by the action of potassium-cyanide on chloroform. By heating these substances along with a considerable quantity of alcohol, a very dark-coloured liquid and mass are obtained, often containing free ammonia. On filtering the warm liquid and distilling off the alcohol, a small portion of very dark-coloured residue is left. The alcohol which passes over contains generally ammonia, hydrocyanic acid, and unaltered chloroform; but the amount of chloroform so obtained I have always found to be much less than that originally employed in the experiment. The same results are obtained whether the materials are heated in well-closed soda-water bottles, or in a flask connected with a reversed Liebig's condenser.

From the residue I have sought to isolate pure cyanoform. I have employed all the methods applied by Dr. Maxwell Simpson and others for the purification of cyanides, as well as other plans thought of by myself, but without success. On one occasion the residues from many operations had been collected and extracted with ether. Some quantity of this ethereal extract was obtained and carefully examined. The result was that it was found to consist in great measure of amylic alcohol, and other substances which were, I believe, impurities in the alcohol employed.

A portion of residue obtained as above having been tested and found free from alkaline cyanides, was heated with sodium. The product contained sodium-cyanide, as proved by the formation of prussian blue from it. Boiled with caustic potash, ammonia is evolved, and the liquid, when neutralized, precipitates ferric chloride; whether this precipitate contains any new acid I did not make many attempts to ascertain.

The hydrogenation of the crude residue gave as final results, chiefly ammonium-salts, but I did not make many experiments on a material which I knew was of uncertain composition.

Two other methods for obtaining cyanoform I have thought of, and made preparations for. One is the action of potassium or other cyanides on bromoform, a small quantity of which I have prepared. The other is to form the nitrite of dichloracetic acid, and to act on it with cyanide of potassium. I have made experiments in this direction, but I am not yet able to report on them.

II. CYANIDE OF ETHYLENE.

I have prepared this body from chloride of ethylene, by Maxwell Simpson's process. Attempts to hydrogenize it gave results which did not agree with one another, but from which I have obtained chiefly succinic acid and salts of ammonia. The experiments made with this body showed the importance of paying particular attention to the strength of acid and proportions of materials used.

III. CYANOGEN &c.

I have resumed experiments on the hydrogenation of this body, as it is the most convenient of these biatomic cyanides. When aqueous solutions and very dilute acid is used to act on the granulated tin, the products are oxalic acid, ammonia, and a small quantity of a base which gives a very deliquescent chloride. In two experiments which gave these results, the acid

was added at intervals during a fortnight, so that altogether it amounted to about five per cent. of the liquid.

I have passed cyanogen and hydrogen, both perfectly dry, over platinum-black heated to 130° C. The tube containing the platinum was not connected till the hydrogen had been passed for about half an hour through the apparatus and drying tubes, and till the cyanogen was given off freely. The hydrogen was dried by passing over five feet of pumice-stone soaked with sulphuric acid. The two gases were mixed in a three-necked Woulfe's bottle, before passing over the platinum. They next passed into an empty bulb apparatus, and then into dilute acid (HCl). On making the connections, dense fumes filled that part of the apparatus next the acid. After some time a small quantity of liquid condensed in the empty bulb apparatus next the platinum. This was found to be strongly alkaline, and was neutralized with hydrochloric acid, and filtered repeatedly from a brown deposit which separated on standing. The determination of the platinum in the platinum-salt gave a result corresponding pretty closely to that which would be given by the platinum-salts of ethylenediamine or methylamine. The quantity of platinum-salt (a little over a decigramme) was, however, too small to give a sufficiently reliable percentage. The platinum-black soon changes, and loses its power. Water then gives with it a very dark-coloured solution, which I have not much examined.

In order to obtain perfectly definite results in the hydrogenation of cyanogen and other cyanides, I have recently adopted the plan of estimating the amount of metal dissolved, and of the hydrogen or other gases evolved, from perfectly known quantities of materials, making each experiment as perfectly quantitative as possible. The experiments which I have made, and those which I am now carrying on, make me confident of being soon able to clear up the difficulties which I have worked at so long unsuccessfully.

Note on the Solubility of Cyanogen in Sulphuric Acid.—Cyanogen dissolves readily in strong sulphuric acid, and is evolved in great measure unchanged on addition of water. The solution of cyanogen in sulphuric acid produces a beautiful purple colour with cuprous cyanide.

Note on the preparation of Olefiant Gas.—Wöhler recommended to add sand to the mixture of sulphuric acid and alcohol to prevent frothing. The objection to this is that the flasks used are very apt to break, by a part of the bottom becoming dry, and the liquid afterwards running down on it. I have found that pumice-stone in small pieces prevents frothing equally well, or better, and since it floats on the liquid, there is much less risk of breakage.

NOTICES AND ABSTRACTS

OF

MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

MATHEMATICS AND PHYSICS.

Address by Professor TYNDALL, *LL.D., F.R.S., &c., President of the Section.*

THE celebrated Fichte, in his lectures on the "Vocation of the Scholar," insisted on a culture for the scholar which should not be one-sided, but all-sided. His intellectual nature was to expand spherically and not in a single direction. In one direction, however, Fichte required that the scholar should apply himself directly to nature, become a creator of knowledge, and thus repay by original labours of his own the immense debt he owed to the labours of others. It was these which enabled him to supplement the knowledge derived from his own researches, so as to render his culture rounded and not one-sided.

Fichte's idea is to some extent illustrated by the constitution and the labours of the British Association. We have here a body of men engaged in the pursuit of Natural Knowledge, but variously engaged. While sympathizing with each of its departments, and supplementing his culture by knowledge drawn from all of them, each student amongst us selects one subject for the exercise of his own original faculty—one line along which he may carry the light of his private intelligence a little way into the darkness by which all knowledge is surrounded. Thus, the geologist faces the rocks; the biologist fronts the conditions and phenomena of life; the astronomer stellar masses and motions; the mathematician the properties of space and number; the chemist pursues his atoms, while the physical investigator has his own large field in optical, thermal, electrical, acoustical, and other phenomena. The British Association, then, faces nature on all sides and pushes knowledge centrifugally outwards, while through circumstance or natural bent each of its working members takes up a certain line of research in which he aspires to be an original producer, being content in all other directions to accept instruction from his fellow men. The sum of our labours constitutes what Fichte might call the *sphere* of natural knowledge. In the meetings of the Association it is found necessary to resolve this sphere into its component parts, which take concrete form under the respective letters of our Sections.

This Section (A) is called the Mathematical and Physical Section. Mathematics and physics have been long accustomed to coalesce, and hence this grouping. For while mathematics, as a product of the human mind, is self-sustaining and nobly self-rewarding, while the pure mathematician may never trouble his mind with considerations regarding the phenomena of the material universe, still the form of reasoning which he employs, the power which the organization of that reasoning confers, the applicability of his abstract conceptions to actual phenomena, render his science one of the most potent instruments in the solution of natural

problems. Indeed without mathematics, expressed or implied, our knowledge of physical science would be friable in the extreme.

Side by side with the mathematical method we have the method of experiment. Here, from a starting-point furnished by his own researches or those of others, the investigator proceeds by combining intuition and verification. He ponders the knowledge he possesses and tries to push it further, he guesses and checks his guess, he conjectures and confirms or explodes his conjecture. These guesses and conjectures are by no means leaps in the dark; for knowledge once gained casts a faint light beyond its own immediate boundaries. There is no discovery so limited as not to illuminate something beyond itself. The force of intellectual penetration into this penumbral region which surrounds actual knowledge is not dependent upon method, but is proportional to the genius of the investigator. There is, however, no genius so gifted as not to need control and verification. The profoundest minds know best that Nature's ways are not at all times their ways, and that the brightest flashes in the world of thought are incomplete until they have been proved to have their counterparts in the world of fact. The vocation of the true experimentalist is the incessant correction and realization of his insight; his experiments finally constituting a body, of which his purified intuitions are, as it were, the soul.

Partly through mathematical and partly through experimental research, physical science has of late years assumed a momentous position in the world. Both in a material and in an intellectual point of view it has produced, and it is destined to produce, immense changes,—vast social ameliorations, and vast alterations in the popular conception of the origin, rule, and governance of things. Miracles are wrought by science in the physical world, while philosophy is forsaking its ancient metaphysical channels and pursuing those opened or indicated by scientific research. This must become more and more the case as philosophic writers become more deeply imbued with the methods of science, better acquainted with the facts which scientific men have won, and with the great theories which they have elaborated.

If you look at the face of a watch, you see the hour- and minute-hands, and possibly also a second-hand, moving over the graduated dial. Why do these hands move? and why are their relative motions such as they are observed to be? These questions cannot be answered without opening the watch, mastering its various parts, and ascertaining their relationship to each other. When this is done, we find that the observed motion of the hands follows of necessity from the inner mechanism of the watch when acted upon by the force invested in the spring.

This motion of the hands may be called a phenomenon of art, but the case is similar with the phenomena of nature. These also have their inner mechanism, and their store of force to set that mechanism going. The ultimate problem of physical science is to reveal this mechanism, to discern this store, and to show that from the combined action of both the phenomena of which they constitute the basis must of necessity flow.

I thought that an attempt to give you even a brief and sketchy illustration of the manner in which scientific thinkers regard this problem would not be uninteresting to you on the present occasion; more especially as it will give me occasion to say a word or two on the tendencies and limits of modern science, to point out the region which men of science claim as their own, and where it is mere waste of time to oppose their advance, and also to define, if possible, the bourn between this and that other region to which the questionings and yearnings of the scientific intellect are directed in vain.

But here your tolerance will be needed. It was the American Emerson, I think, who said that it is hardly possible to state any truth strongly without apparent injury to some other truth. Under the circumstances, the proper course appears to be to state both truths strongly, and allow each its fair share in the formation of the resultant conviction. For truth is often of a dual character, taking the form of a magnet with two poles; and many of the differences which agitate the thinking part of mankind are to be traced to the exclusiveness with which different parties affirm one half of the duality in forgetfulness of the other half. But this waiting for the statement of the two sides of a question implies patience. It implies a reso-

lution to suppress indignation if the statement of the one half should clash with our convictions, and not to suffer ourselves to be unduly elated if the half-statement should chime in with our views. It implies a determination to wait calmly for the statement of the whole, before we pronounce judgment either in the form of acquiescence or dissent.

This premised, let us enter upon our task. There have been writers who affirmed that the pyramids of Egypt were the productions of nature; and in his early youth Alexander von Humboldt wrote an essay with the express object of refuting this notion. We now regard the pyramids as the work of men's hands, aided probably by machinery of which no record remains. We picture to ourselves the swarming workers toiling at those vast erections, lifting the inert stones, and, guided by the volition, the skill, and possibly at times by the whip of the architect, placing the stones in their proper positions. The blocks in this case were moved by a power external to themselves, and the final form of the pyramid expressed the thought of its human builder.

Let us pass from this illustration of building power to another of a different kind. When a solution of common salt is slowly evaporated, the water which holds the salt in solution disappears, but the salt itself remains behind. At a certain stage of concentration the salt can no longer retain the liquid form; its particles, or molecules, as they are called, begin to deposit themselves as minute solids, so minute, indeed, as to defy all microscopic power. As evaporation continues solidification goes on, and we finally obtain, through the clustering together of innumerable molecules, a finite mass of salt of a definite form. What is this form? It sometimes seems a mimicry of the architecture of Egypt. We have little pyramids built by the salt, terrace above terrace from base to apex, forming thus a series of steps resembling those up which the Egyptian traveller is dragged by his guides. The human mind is as little disposed to look at these pyramidal salt-crystals without further question, as to look at the pyramids of Egypt without inquiring whence they came. How, then, are those salt-pyramids built up?

Guided by analogy, you may suppose that, swarming among the constituent molecules of the salt, there is an invisible population, guided and coerced by some invisible master, and placing the atomic blocks in their positions. This, however, is not the scientific idea, nor do I think your good sense will accept it as a likely one. The scientific idea is that the molecules act upon each other without the intervention of slave labour; that they attract each other and repel each other at certain definite points, and in certain definite directions; and that the pyramidal form is the result of this play of attraction and repulsion. While, then, the blocks of Egypt were laid down by a power external to themselves, these molecular blocks of salt are self-posited, being fixed in their places by the forces with which they act upon each other.

I take common salt as an illustration because it is so familiar to us all; but almost any other substance would answer my purpose equally well. In fact, throughout inorganic nature, we have this formative power, as Fichte would call it—this structural energy ready to come into play, and build the ultimate particles of matter into definite shapes. It is present everywhere. The ice of our winters and of our polar regions is its handywork, and so equally are the quartz, felspar, and mica of our rocks. Our chalk-beds are for the most part composed of minute shells, which are also the product of structural energy; but behind the shell, as a whole, lies the result of another and more subtle formative act. These shells are built up of little crystals of calc-spar, and to form these the structural force had to deal with the intangible molecules of carbonate of lime. This tendency on the part of matter to organize itself, to grow into shape, to assume definite forms in obedience to the definite action of force, is, as I have said, all-pervading. It is in the ground on which you tread, in the water you drink, in the air you breathe. Incipient life, in fact, manifests itself throughout the whole of what we call inorganic nature.

The forms of minerals resulting from this play of forces are various. and exhibit different degrees of complexity. Men of science avail themselves of all possible means of exploring this molecular architecture. For this purpose they employ in turn as agents of exploration, light, heat, magnetism, electricity, and sound.

Polarized light is especially useful and powerful here. A beam of such light, when sent in among the molecules of a crystal, is acted on by them, and from this action we infer with more or less of clearness the manner in which the molecules are arranged. The difference, for example, between the inner structure of a plate of rock-salt and a plate of crystallized sugar or sugar-candy is thus strikingly revealed. These differences may be made to display themselves in phenomena of colour of great splendour, the play of molecular force being so regulated as to remove certain of the coloured constituents of white light, and to leave others with increased intensity behind.

And now let us pass from what we are accustomed to regard as a dead mineral to a living grain of corn. When *it* is examined by polarized light, chromatic phenomena similar to those noticed in crystals are observed. And why? Because the architecture of the grain resembles in some degree the architecture of the crystal. In the corn the molecules are also set in definite positions, from which they act upon the light. But what has built together the molecules of the corn? I have already said regarding crystalline architecture that you may, if you please, consider the atoms and molecules to be placed in position by a power external to themselves. The same hypothesis is open to you now. But if in the case of crystals you have rejected this notion of an external architect, I think you are bound to reject it now, and to conclude that the molecules of the corn are self-posited by the forces with which they act upon each other. It would be poor philosophy to invoke an external agent in the one case and to reject it in the other.

Instead of cutting our grain of corn into thin slices and subjecting it to the action of polarized light, let us place it in the earth and subject it to a certain degree of warmth. In other words, let the molecules, both of the corn and of the surrounding earth, be kept in a state of agitation; for warmth, as most of you know, is, in the eye of science, tremulous molecular motion. Under these circumstances, the grain and the substances which surround it interact, and a molecular architecture is the result of this interaction. A bud is formed; this bud reaches the surface, where it is exposed to the sun's rays, which are also to be regarded as a kind of vibratory motion. And as the common motion of heat with which the grain and the substances surrounding it were first endowed, enabled the grain and these substances to coalesce, so the specific motion of the sun's rays now enables the green bud to feed upon the carbonic acid and the aqueous vapour of the air, appropriating those constituents of both for which the blade has an elective attraction, and permitting the other constituent to resume its place in the air. Thus forces are active at the root, forces are active in the blade, the matter of the earth and the matter of the atmosphere are drawn towards the plant, and the plant augments in size. We have in succession the bud, the stalk, the ear, the full corn in the ear. For the forces here at play act in a cycle which is completed by the production of grains similar to that with which the process began.

Now there is nothing in this process which necessarily eludes the power of mind as we know it. An intellect the same in kind as our own would, if only sufficiently expanded, be able to follow the whole process from beginning to end. No entirely new intellectual faculty would be needed for this purpose. The duly expanded mind would see in the process and its consummation an instance of the play of molecular force. It would see every molecule placed in its position by the specific attractions and repulsions exerted between it and other molecules. Nay, given the grain and its environment, an intellect the same in kind as our own, but sufficiently expanded, might trace out *à priori* every step of the process, and by the application of mechanical principles would be able to demonstrate that the cycle of actions must end, as it is seen to end, in the reproduction of forms like that with which the operation began. A similar necessity rules here to that which rules the planets in their circuits round the sun.

You will notice that I am stating my truth strongly, as at the beginning we agreed it should be stated. But I must go still further, and affirm that in the eye of science *the animal body* is just as much the product of molecular force as the stalk and ear of corn, or as the crystal or salt of sugar. Many of its parts are obviously mechanical. Take the human heart, for example, with its exquisite system of valves, or take the eye or the hand. Animal heat, moreover, is the same in kind

as the heat of a fire, being produced by the same chemical process. Animal motion, too, is as directly derived from the food of the animal, as the motion of Trevethyck's walking-engine from the fuel in its furnace. As regards matter, the animal body creates nothing; as regards force, it creates nothing. Which of you by taking thought can add one cubit to his stature? All that has been said regarding the plant may be restated with regard to the animal. Every particle that enters into the composition of a muscle, a nerve, or a bone, has been placed in its position by molecular force. And unless the existence of law in these matters be denied, and the element of caprice introduced, we must conclude that, given the relation of any molecule of the body to its environment, its position in the body might be predicted. Our difficulty is not with the *quality* of the problem, but with its *complexity*; and this difficulty might be met by the simple expansion of the faculties which man now possesses. Given this expansion, and given the necessary molecular data, and the chick might be deduced as rigorously and as logically from the egg as the existence of Neptune was deduced from the disturbances of Uranus, or as conical refraction was deduced from the undulatory theory of light.

You see I am not mincing matters, but avowing nakedly what many scientific thinkers more or less distinctly believe. The formation of a crystal, a plant, or an animal, is in their eyes a purely mechanical problem, which differs from the problems of ordinary mechanics in the smallness of the masses and the complexity of the processes involved. Here you have one half of our dual truth; let us now glance at the other half. Associated with this wonderful mechanism of the animal body we have phenomena no less certain than those of physics, but between which and the mechanism we discern no necessary connexion. A man, for example, can say *I feel, I think, I love*; but how does *consciousness* infuse itself into the problem? The human brain is said to be the organ of thought and feeling; when we are hurt the brain feels it, when we ponder it is the brain that thinks, when our passions or affections are excited it is through the instrumentality of the brain. Let us endeavour to be a little more precise here. I hardly imagine that any profound scientific thinker, who has reflected upon the subject, exists who would not admit the extreme probability of the hypothesis, that for every fact of consciousness, whether in the domain of sense, of thought, or of emotion, a certain definite molecular condition is set up in the brain; that this relation of physics to consciousness is invariable, so that, given the state of the brain, the corresponding thought or feeling might be inferred; or given the thought or feeling, the corresponding state of the brain might be inferred. But how inferred? It is at bottom not a case of logical inference at all, but of empirical association. You may reply that many of the inferences of science are of this character; the inference, for example, that an electric current of a given direction will deflect a magnetic needle in a definite way; but the cases differ in this, that the passage from the current to the needle, if not demonstrable, is thinkable, and that we entertain no doubt as to the final mechanical solution of the problem; but the passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought, and a definite molecular action in the brain occur simultaneously; we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass by a process of reasoning from the one phenomenon to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem, "How are these physical processes connected with the facts of consciousness?" The chasm between the two classes of phenomena would still remain intellectually impassable. Let the consciousness of *love*, for example, be associated with a right-handed spiral motion of the molecules of the brain, and the consciousness of *hate* with a left-handed spiral motion. We should then know when we love that the motion is in one direction, and when we hate that the motion is in the other; but the "WHY?" would still remain unanswered.

In affirming that the growth of the body is mechanical, and that thought, as

exercised by us, has its correlative in the physics of the brain, I think the position of the "Materialist" is stated as far as that position is a tenable one. I think the materialist will be able finally to maintain this position against all attacks; but I do not think, as the human mind is at present constituted, that he can pass beyond it. I do not think he is entitled to say that his molecular groupings and his molecular motions explain everything. In reality they explain nothing. The utmost he can affirm is the association of two classes of phenomena, of whose real bond of union he is in absolute ignorance. The problem of the connexion of body and soul is as insoluble in its modern form as it was in the prescientific ages. Phosphorus is known to enter into the composition of the human brain, and a courageous writer has exclaimed, in his trenchant German, "Ohne Phosphor kein Gedanke." That may or may not be the case; but even if we knew it to be the case, the knowledge would not lighten our darkness. On both sides of the zone here assigned to the materialist he is equally helpless. If you ask him whence is this "matter" of which we have been discoursing, who or what divided it into molecules, who or what impressed upon them this necessity of running into organic forms, he has no answer. Science also is mute in reply to these questions. But if the materialist is confounded and science rendered dumb, who else is entitled to answer? To whom has the secret been revealed? Let us lower our heads and acknowledge our ignorance one and all. Perhaps the mystery may resolve itself into knowledge at some future day. The process of things upon this earth has been one of amelioration. It is a long way from the Iguanodon and his contemporaries, to the President and Members of the British Association. And whether we regard the improvement from the scientific or from the theological point of view, as the result of progressive development, or as the result of successive exhibitions of creative energy, neither view entitles us to assume that man's present faculties end the series,—that the process of amelioration stops at him. A time may therefore come when this ultra-scientific region by which we are now enfolded may offer itself to terrestrial, if not to human investigation. Two-thirds of the rays emitted by the sun fail to arouse in the eye the sense of vision. The rays exist, but the visual organ requisite for their translation into light does not exist. And so from this region of darkness and mystery which surrounds us, rays may now be darting which require but the development of the proper intellectual organs to translate them into knowledge as far surpassing ours as ours does that of the wallowing reptiles which once held possession of this planet. Meanwhile the mystery is not without its uses. It certainly may be made a power in the human soul; but it is a power which has feeling, not knowledge, for its base. It may be, and will be, and we hope is turned to account, both in steadying and strengthening the intellect, and in rescuing man from that littleness to which, in the struggle for existence, or for precedence in the world, he is continually prone.

On the Necessity for State Intervention to secure the Progress of Physical Science. By Lieut.-Col. A. Strange, *F.R.S., Government Inspector of Scientific Instruments, India Department.*

The author pointed out that physical science, like literature and the fine arts, requires to be *taught*, to be *extended*, and to be *exhibited*; that the necessity for teaching science in schools and universities is now generally admitted; that the results of science are very fully exhibited in all civilized communities; but that the provision for extending the boundaries of scientific knowledge in England is inadequate and unsystematic. After enumerating some of the institutions, national and corporate, in which certain branches of science are cultivated, the author remarked that these are too limited in their objects, their scope, and their number to collect the data, and to push on with the necessary promptitude the investigations of which we stand in need. The paper urges that the period is gone by when science generally can be cultivated with simple and primitive means; and that the required researches of the present day need for their successful prosecution buildings expressly constructed for the purpose, extensive and costly appliances, and the continuous employment of the highest skill. It is evident that these re-

quirements cannot be met by private enterprise and munificence, or even by corporate bodies supported by private contributions. These postulates being admitted, it follows of necessity that the resources of the State alone can adequately supply the existing want; and that unless these are so employed the progress of scientific knowledge and discovery must become slower and slower.

Without entering into premature details, the paper proposes that there should be established a system of national institutions for the sole purpose of advancing science by practical research, *quite apart from teaching it*; that such institutions, provided with extensive appliances and skilled operators, should be presided over by a governing body constituted with reference solely to the scientific eminence of its members, or, which would be better, by a single chief, directly responsible to a Minister of State, as now proposed for the British Museum. That this body or chief should direct the labours of the Executive into such fields as they may deem most worthy of being explored; and that they should also have the power of sanctioning experiments and investigations proposed by any person unconnected with them, thus rendering the institution as much as possible accessible to the scientific public, and to persons whose objects, manufacturing or other, require for their promotion physical data which they may possess neither the skill nor the appliances to obtain. Publication of results should also be duly provided for. The paper observes that such institutions would form a consultative body to which the State would resort for that advice and assistance which is now sought to be obtained by the very costly and not always very satisfactory expedient of special commissions. The advantages which the nation derives from the results of science, cultivated even as it is at present, desultorily and inefficiently, would be enormously multiplied by the introduction of the principle of continuity in research, and by the employment of the highest skill and the most perfect appliances. Systematic investigation conducted in the comprehensive manner proposed must prove directly remunerative, whether applied to strictly State purposes, or whether utilized in the public works, the manufactures, and the general necessities of the nation.

The objections that may be urged against the present proposal are then touched on. The chief of these are:—First, that such State institutions would tend to chill private enterprise. The reply is, that in certain departments of science the State has long been compelled to intervene. National observatories, surveys, and museums are instanced. These rather tend to stimulate than to restrain the private cultivation of science. But it is assumed, as the very foundation of the present paper, that private scientific enterprise, great as it is in England, does not satisfy the present demands for physical data and laws; and therefore, if State intervention may be expected to satisfy those demands, the risk of discouraging the present insufficient agency must be incurred. And it is maintained that the tendency of progressive civilization must be to supersede individual effort. Secondly, that such a system as that proposed would bring with it abuses and jobbery. Let this be admitted with regard to science in common with every human organization. Every profession and every branch of the public service suffers from the inevitable evil. But in spite of obvious corruption and favouritism, we still keep up an army, a navy, and a parliament. The greatest care must be taken to exclude abuses; and those that will undoubtedly gain admission must be considered as part of the price paid for the advantages obtained. There are no grounds for imputing to science any special capacity for corruption. Thirdly, that the amount of work to be done may not prove sufficient for the continuous employment of very extensive establishments. The paper, however, assumes the contrary; its limits do not admit of the discussion of this objection, which would be submitted for the opinions of the men most eminent in physical research. After a brief recapitulation, the paper concludes thus:—

" Every visitor to this Congress of Science receives a printed paper, in which he is told that

"'The objects of the British Association are to give a *stronger* impulse and more *systematic* direction to scientific inquiry,' and 'to remove any disadvantages of a public kind which impede its progress.'

"These words define, as precisely as if they had been written for the express purpose, the aims of the present proposal. It is for this powerful and enlightened Body to consider whether such an investigation of the subject shall be instituted as may serve to direct and impel public opinion in a channel which the educated classes of Englishmen seem now disposed to enter—insisting on the value and the comparatively backward condition of physical research, and indicating the means best fitted to place at man's disposal, systematically and promptly, the intellectual glories and the material riches which a bounteous Providence has created for his use."

Mathematics.

A historical Note on Lagrange's Theorem. *By* W. Barrett Davis.

On a new Correction to be applied to observations made with Hadley's Sextant. *By* T. Dobson.

Résumé of Experiments on Rigidity. *By* Professor J. D. Everett, *D.C.L.*

After pointing out the relations which connect Young's modulus of elasticity, simple rigidity, resistance to cubic compression, and the ratio of lateral contraction to longitudinal extension, in isotropic substances, which relations are such that if any two of these coefficients are given the other two can be inferred, the author proceeded to describe the method by which he had determined experimentally the values of the two first-mentioned coefficients, and had hence derived the values of the other two. The method consisted in applying a given couple to bend and twist alternately one and the same portion of a cylindrical rod. The especial object of investigation was the coefficient called "Poisson's ratio," that is to say, the ratio which the lateral contraction of a rod bears to its longitudinal extension when it is forcibly lengthened within the limits of elasticity, which ratio was erroneously supposed by Poisson to have the constant value $\frac{1}{4}$ for all substances.

In order to determine the value of this coefficient for any particular isotropic substance, it was only necessary to compare the amounts of bending and twisting produced in a given portion of a cylindrical rod by couples of equal moment. Let T denote the amount of twisting, F the amount of bending, and σ Poisson's ratio, then $\sigma=\frac{T}{F}-1$.

In this way the following values of σ had been found for one specimen of each of the undermentioned substances:—flint-glass, ·229; drawn brass, ·469; drawn steel, ·310; wrought iron, ·275; cast iron, ·267; copper, ·378.

Examples of Ocular Demonstration of Geometrical Propositions. *By* Arthur Gearing.

The object of this communication was to demonstrate the possibility of any given geometrical form or forms being reduced to any other required geometrical figure without loss of material, and of equal area to the given number of contained counterparts.

As tests for instrumental measurements and as discipline for the hand of the artist, the series suggested exact and interesting exercises in practical geometry, and might be used in the economy of adjusting materials. The examples (above 50 in number) comprise the reduction of regular polygons of any number of sides to squares and other figures with the same identical number of counterparts, each figure having some special distinction. The whole series could be cut out in paper, and a given figure made into another figure, thus constituting by ocular demonstration an additional means of testing great geometrical truths as a pleasing experimental exercise.

On the Chances of Success or Failure of Candidates for three-cornered or four-cornered Constituencies. By R. B. HAYWARD, *M.A.*

This paper discussed some of the consequences involved in the system of voting now in force for constituencies returning three or four representatives, by which no voter can vote for more than two candidates in the one case or for more than three in the other.

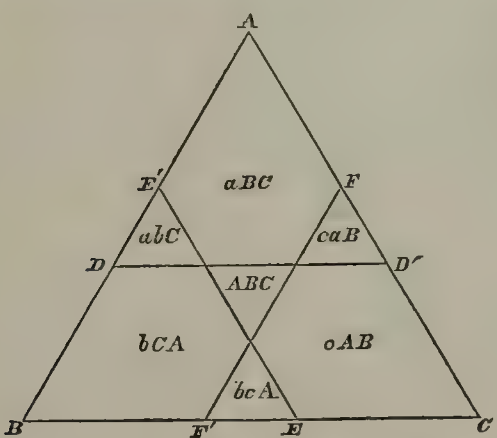
Suppose a majority of M voters to bring forward three candiates A, B, C, while the minority of m voters bring forward two, and that, of the majority M, x vote for B and C, y for C and A, and z for A and B; then, supposing that each of the M voters gives both his votes,

$$x+y+z=\mathrm{M}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(I.)}$$

The event of the success of A may be denoted by A, and the corresponding condition is $y+z>m$; the event of his failure by a, and the condition is $y+z<m$. So also a compound event, *e. g.* the success of A and failure of B and C, may be denoted by A b c, and the corresponding conditions are $y+z>m$, $z+x<m$, $x+y<m$.

The different possible events are then A B C, aB C, b C A, c A B, A b c, B c a, C a b, and the question discussed was the determination of the relative numbers of the cases favourable to these different events for different relative values of M and m, or the relative numbers of positive integral solutions (including 0) of the above equation subject to the different conditions corresponding to the different events. It was shown that this discussion was much facilitated by a simple geometrical representation. A number of points uniformly distributed over an equilateral triangle being taken to represent the total number of possible distributions of the M votes or the total number of solutions of the equation (1.), each point corresponding to one solution determinable from its position in the triangle, the numbers of points within the different areas into which the triangle is divided by lines properly drawn parallel to the sides, represent the cases favourable to the different possible events. Thus the relative numbers of these cases are rendered evident and easily calculated.

The figure annexed is drawn to represent the case where $m=\frac{3}{5}\mathrm{M}$. If each side of the triangle be 5, each of the lengths A D, A D′, B E, B E′, C F, C F′ is 3, and



the seven spaces correspond to the seven possible events marked within them. The relative numbers of cases favourable to the different events will be readily seen to be 1, 1, 1, 1, 7, 7, 7, if the number of voters be large, so that an area may be taken as proportional to the number of points within it.

If each individual distribution of the votes, or, in other words, each solution of (I), were equally probable, these numbers would represent the relative probabilities of the different events; but this is far from being the case, the *weight* of each

solution being in fact represented by $\frac{\Gamma(M+1)}{\Gamma(x+1) \cdot \Gamma(y+1) \cdot \Gamma(z+1)}$, which varies from unity at the corners of the triangle up to the very large number $\frac{\Gamma(M+1)}{\left\{\Gamma\left(\frac{M}{3}+1\right)\right\}^3}$ at its centre. No simple and easy method of evaluating precise numerical results for the probabilities of the different cases is attainable; but it will readily be seen that conclusions of a general nature, not without interest and importance, may notwithstanding be obtained in any given case.

Analogous considerations applied to a four-cornered constituency lead to a representation of the different cases by the portions into which a tetrahedron is divided by planes parallel to its four faces.

On the Division of Elliptic Functions. By W. H. L. Russell, *F.R.S.*

This paper was intended to illustrate some of the discoveries of Dr. Weierstrass. It was shown that certain series for sin $am \,.\, u$, assumed to be convergent for certain values of (u) when sufficiently small, are true when (u) has any value. The proof depended on an application of the proposition known as Abel's Theorem.

On a construction for the Ninth Cubic Point.
By Professor H. J. Stephen Smith, *F.R.S.*

On Geometrical Constructions involving imaginary data.
By Professor H. J. Stephen Smith, *F.R.S.*

On a property of the Hessian of a Cubic Surface.
By Professor H. J. Stephen Smith, *F.R.S.*

On the Successive Involutes to a Circle. By J. J. Sylvester.

From the first involute of a circle we may derive a family of parallel curves forming the second involutes of the circle; from each of these again families, the totality of which will form the third involutes, and so on continually.

The author had been led by circumstances to study the arco-radial or semi-intrinsic equation of these curves, and had arrived at certain conclusions concerning its form which subsequent investigations have verified: it turns out that the general equation between the arc s and radius vector r of the general involute of the nth degree will be found by taking F, any rational integer function of x of the nth degree, and eliminating x between the equations $r^2=F^2+\left(\frac{dF}{dx}\right)^2$,

$$s=\int dx F+\frac{dF}{dx}$$

It follows, as the author had surmised, that the general arco-radial equation for the involute of the nth order when n exceeds unity, is of the degree $(n+1)$ in r^2 and $2n$ in s. Of course, in the case of n equal to unity, the degrees sink to 1 in r^2 and 1 in s. The second involute formed by unwrapping from the cusp of the first may be termed the natural second involute, but is not the most simple of the family; this, which is at the normal distance of half the radius externally from the one last named, is of the third degree in r and the second in s. It may be derived from the curve which a fixed point in a wall at half the length of the radius of a wheel from the ground marks in the wheel as it rolls along the face of the wall by doubling the vectorial angles and taking the square out of the radii vectores. From the arco-radial it is easy to pass to the general polar equation to the n-ary involute; the equation between p, the perpendicular from the centre and q the polar subtangent, is also very easily obtained, being, in fact, no other than the result

of eliminating between $Fx=p$, $F'x=q$, Fx being any quantic in x of the nth degree, so that this equation will be of the $(n-1)$th order in q, and the nth order in p.

In the Philosophical Magazine for October and December, and in the Proceedings of the Mathematical Society of London, will be found further developments of the theory of these circular involutes, which it is proposed to term Cyclodes.

On the application of Quaternions to the rotation of a Solid. *By* Professor P. G. Tait.

Astronomy.

On the extent of evidence which we possess elucidatory of "change" on the Moon's Surface. *By* W. R. Birt, *F.R.A.S.*

The questions of change on, or fixity of the moon's surface must be decided, as Webb (Celestial Objects for Common Telescopes, second edition, p. 68) remarks, by observation and not assertion. It is therefore important to gather up the fragments of our knowledge bearing on the evidence which we possess on these questions; and we may remark, in the first place, that our *real* knowledge of the *fixity* of the moon's surface does not *at present* depend upon "evidence," using this term to designate the results of observation and not the deductions of theory; nor can we possess any adequate evidence of this kind, as is manifest from the very circumstance that up to the present moment our records of the physical aspect of the moon's surface are not only exceedingly scanty—in comparison with the countless thousands of objects of every variety of description which are revealed to us by even small instruments, let alone the increasing visibility of smaller objects due to larger apertures—but it is now becoming acknowledged that such records and the delineations accompanying them are not sufficiently precise and exact to enable us to refer to them as reliable witnesses in *establishing* "fixity;" indeed it is difficult to conceive how the *unalterable* state of the moon's surface can be determined by "observation." If, as has been asserted, all changes on the moon's surface have ceased *myriads of ages ago,* we are certainly destitute of the records of "observation" of the real state of that surface at so remote a period. In fact our absolute knowledge of "fixity" can only date from the construction of the first lunar map, since which there are no traces of any grand convulsion. The establishment of "fixity" can only have reference to those objects which have been more particularly observed during the intervening period; and, as shown by Webb (Intellectual Observer, vol. xii. pp. 435, 436), if really established by a long course of observation at any one point, it would be no argument for its universal prevalence, since a state of quiescence might be attained at very different epochs in different regions.

Such being the case as regards "fixity," let us now inquire as to what evidence we possess on the subject of "change." The earliest attempts to perpetuate a knowledge of the moon's surface consisted in delineating the disk in the form of maps, accompanied in *two* instances with "catalogues" of the most striking and prominent objects; but, as might be expected, such maps are greatly destitute of "detail," especially of such a character as is necessary to pronounce on "change." Towards the close of the last century Schröter, seeing the importance of perpetuating a knowledge of detail, bequeathed to us the result of his labours in this direction in the form of his 'Selenotopographische Fragmente,' taking up portions of the moon rather than attempting a delineation of the whole in detail. His successors, Lohrmann, Beer and Mädler, and Schmidt, have followed in his steps, and produced works abounding much more in detail than any of the predecessors of Schröter; Lohrmann's sections and map, with the two maps of Mädler, are well known. The larger portion of Lohrmann's Sections, as well as the results of Schmidt's labours, are still unpublished. Webb's index map of the moon in his

'Celestial Objects', with two catalogues of the principal craters, &c., together form an excellent guide to observers who are *commencing* the study of "detail."

It is by means of the study of "detail" that a definitive answer must be given to either of the questions mentioned at the commencement of this paper. The details of the moon's surface are very various; mountain-chains, towering peaks, isolated hills, deep valleys, extensive plains scored with comparatively low ridges, crater-openings, in some localities crowded together by thousands, in others occurring singly, and situated far apart from each other, rings (apparently the highest parts of crater walls) the interiors of which convey the idea of having been partially filled with an injected material, minute craters are not unfrequent on their surfaces; bright spots, often of a dazzling whiteness, marking the tops of mountains and the crests of mountain-chains, as well as others of less brilliancy and greater indistinctness of outline; dark spots surrounded in some cases by bright rims; in others the difference between the dark spots and the comparatively lighter surface is rendered distinctly visible by a sharp outline inclosing the dark surface. All these varieties must be carefully studied before a conclusion can be drawn as to the unalterable stability or mutation of such objects.

The means which we possess for the study of lunar objects may be considered as twofold,—the examination of delineations and topographical notices on the one hand, and personal observation of the objects themselves on the other, of course including a comparison of one with the other. For example, we may find on the moon a spot darker than any object in the immediate locality surrounded by a rim brighter than the exterior surface, and we record its appearance. It is now desirable to place in juxtaposition all the records we possess of it as under.

Beer and Mädler, in 'Der Mond,' p. 304, thus describe two craters on the *Mare Nubium*. I am indebted to W. T. Lynn, Esq., of the Royal Observatory, Greenwich, for the translation.

"The boundary of the *Mare Nubium* does not run alongside of Alpetragius, but passes by it under several deep curvatures from three to five miles [German] to the eastward. In the Mare itself is situated the bright radiating crater B (9° light) at −14° 55′ lat. and −7° 27′ long., and near this the far larger and deeper one a, which, however, is found with difficulty at the full moon. It is about $4\frac{1}{2}$°, and the interior 3° bright (Insula Lesbos H)."

As it is important that nothing should be quoted from memory unless quite unavoidable, the following are extracts from my note-book.

1868. June 29, 8.40. Crossley Equatorial, 7·3 inches aperture, power 122.

"B. & M.'s a and B are both quite conspicuous; a is a shallow crater or ring with a smooth floor; interior west shadow very narrow between 0·1 and 0·2, the diameter of a being 1·0. B is a deep and bright crater, shadow gibbous =0·5."

1868. July 29, 10.30, Royal Astronomical Society's Sheepshanks telescope No. 5, aperture 2·75 inches, power 100.

"The interior of a very dark, the *darkest* surface in the locality, probably ·2°."

1868. July 31, 10.15, R. A. S. Sheepshanks No. 5, power 109.

"The floor of a is *darker* than any surrounding part; all three authorities, Lohrmann, Mädler, and Schmidt, make it lighter than the surface of the *Mare*."

The following brightnesses were determined:—

	July 31, 10.15 to 10.50.	August 1, 11.45.
Alpetragius	d=0·8	0·8
,,	B=0·8	0·8
Mare Nubium	=0·2	0·2
Alpetragius	a=0·175	0·15
Billy	=0·05	0·10
Border Alpetragius a=		0·4

Written from memory, Aug. 2 7h. "On the evening of the 1st, the line of demarcation between the surface of the Mare Nubium and the adjacent lighter parts was very distinct."

With such facts before us can we decide for "change?" In replying to this question one disadvantage immediately suggests itself. We are uncertain as to the number of observations on which the earlier records rest; but while in doubt

on this point, we have it in our power not only to increase our own observations, but also to solicit the aid of others, that in the re-observation of an object the want of confirmatory evidence may not exist to occasion a doubt as to the certainty of what is recorded. Webb says very truly (Celestial Objects, second edition, p. 68), we are scarcely as yet possessed of the means of detecting small changes. The evidence capable of being brought to bear on the question of change is consequently very limited in extent, especially as former records are more or less open to be regarded as inexact drawings or inaccurate statements when they happen to differ from present observed appearances, still as instances such as are given above *increase*, and they are upon the increase, it will become more and more difficult to put aside the earlier records. It therefore remains rather, as recommended by M. de Beaumont, to increase our observations and compare them with the earlier records than to rest satisfied with the notion that, as no change has been satisfactorily ascertained, it is unlikely upon certain theoretical considerations that we may meet with any.

The Meteor Shower of August 1868. *By* George Forbes.

The author merely stated the results of some observations made on this shower on the nights of the 10th–11th and 11th–12th of August last. The peculiarities of this shower were for the most part the same as last year. The hourly average number on the first night was 21 on a clear night seen by one person, while last year the number was 25 on a hazy night by the same person. The radiant-point was approximately R.A. 2^h 16^m N.P.D 31°. Last year it was nearly the same. Two meteors traced curves, one of them of a very remarkable form. When a distinct train was left the meteor was generally noticed to pass beyond the end of the train and to become suddenly extinguished *without previous diminution of brilliancy.* No trace of the radiant discovered last year in Pisces was noticed. The average size of meteors was that of a 4th magnitude star.

Acoustics.

*On a Simple Method of exhibiting the Combination of Rectangular Vibrations**. *By* W. Fletcher Barrett.

Physicists are well acquainted with the elegant experiments of M. Lissajous, in which the vibrations of two tuning-forks, placed at rectangles, are optically combined by viewing a ray of light successively reflected from a mirror attached to each fork. A regular series of curves is thus obtained which gives a perfect optical expression of each of the musical intervals, the curves augmenting in complexity as the dissonance between the forks increases.

Instructive and beautiful as are these experiments, the extreme costliness of the apparatus necessary for their proper exhibition has hiherto debarred many from repeating them.

Upwards of two years ago the author found a method of obtaining any desired combination by an extremely simple arrangement. A piece of straightened steel wire, about No. 16 gauge and some 12 or 18 inches long, is first well softened in a flame at a point 6 or 8 inches from the end, which length is then bent downwards. The extremity of the longer portion is fixed in a vice, a silvered bead is cemented by marine glue on to the summit of the bend, and the instrument is complete. The whole system is thrown into vibration by smartly tapping the wire near the point held in the vice, and *in a direction oblique to the plane of the two wires.* The vibration travels up the wire, rounds the bend, and throws the inclined arm into motion. The latter, being free, vibrates more easily than the portion which is fixed at one extremity; a compound motion is thus the result, and the spot of light, reflected from the bead, describes a curve expressing the resultant action.

The ratio between the vibrations of the two parts of the wire can evidently be adjusted, or altered, by raising or lowering the point clamped in the vice. The same end may also be obtained by loading the free portion of the wire by a little

* Published *in extenso* in the Philosophical Magazine for September 1868.

sliding weight. But an alteration in the angle of the bent wire yields a more satisfactory result. When the wires are parallel and even in length, a combination of 1 to 1 is obtained, and the bead describes a circle passing into an oblique line; but on opening the free limb to an angle of about 30°, the figure changes into the complex curve given by the ratio of 4 to 5. Opening the angle still further, the curve expressing the ratio of 3 to 4 is obtained; then at 45° 2 to 3; and at an angle of 75° the figure of eight comes out, expressing the ratio of 1 to 2. In fact, by varying the angle an entire series of combinations, more or less perfect, can be produced at will.

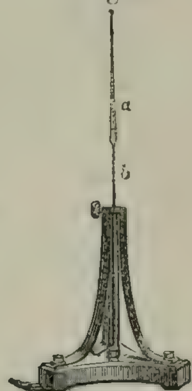
Figure 1 shows the instrument. The wire is capable of being *firmly* fixed at any height in a support which is attached to a heavy stand, more convenient in use than a vice.

Not only may this arrangment be used for exhibiting the combination of vibrations, but it also shows very prettily the formation of nodes and ventral segments.

On the free arm an instructive change is seen to take place in the position of a node which is there formed. When the arms are equal and parallel, and a ratio of 1 to 1 obtained, the node is near the free extremity of the bent wire; as

Fig. 1.

Fig. 2.



the wire is raised and the angle increases, the node rises nearer to the bend. It is also worth observing that, in any combination, the distance of the node from the free extremity of the wire, compared with its distance from the bend, is approximately the same as the ratio of the interval depicted by the figure.

Another arrangement for effecting the combination of rectanglar vibrations (shown in figure 2) has been adapted by Mr. Ladd from an instrument devised by Professor Helmholtz.

Two flat pieces of steel are here welded at right angles to each other into a single rod. The upper part (*a*, fig. 2) is tapering, and on its summit is fixed a polished silver bead. The lower part (*b*) is capable of being firmly fixed in a suitable support. According to the height at which *b* is clamped, so a corresponding portion is allowed to enter into vibration. A combination of the vibration of *a* with that of *b* can thus be obtained in any given ratio. Complete command of any figure can be had by marking its position on the lower strip of steel; and so nice an adjustment is possible, that an almost absolutely steady figure can be secured with a little care.

The author proposes to call the instrument described in this paper a *Tonophant.*

HEAT.

On Sources of Error in determinations of the Absorption of Heat by Liquids. *By* W. FLETCHER BARRETT*.

During the autumn of 1865 the author had observed that under certain condi-

* Published *in extenso* in the Philosophical Magazine for September 1868.

tions the more diathermic liquids exhibited a remarkable and anomalous deportment towards radiant heat. This observation led him to make a subsequent investigation, the results of which are summed up as follows:—

When the more diathermic liquids are introduced between two parallel plates of rock-salt separated by a very small interval, the rays from an artificial source are found to be more freely transmitted than when air intervenes between the plates. For a space of ·02 inch wide the increased transmission amounts with bichloride of carbon to about 12 per cent., with bisulphide of carbon to 9 per cent., and with chloroform to 4·5 per cent. This effect disappears and less heat is transmitted (1) when the transcalency of the liquid diminishes; *e. g.* the same thickness of sulphuric ether intercepts 30 per cent. of the heat previously passing through the empty cell; (2) when the distance between the plates is increased beyond, say, $\frac{1}{10}$ of an inch in the case of bisulphide, and $\frac{1}{10}$ of an inch in the case of bichloride of carbon. The increased transmission by these liquids reappears, however, in thicker layers when plane parallel *glass* plates are substituted for rock-salt, and continues, apparently indeed augmenting, as the depth of the cell increases, so far as the experiments were carried. Bisulphide of carbon, poured into a cell with glass sides 1·2 inch apart, increases the heat falling on the pile 6 per cent., and bichloride of carbon a still larger amount. Altering the temperature or nature of the source, the size of the aperture in a screen behind the cell, or the position of the cell, makes no material change in these results. But altering the character, or augmenting the thickness, of the walls of the cell has considerable influence. For example, if the cell-walls be of glass, increasing their thickness from one- to three-tenths of an inch raises the heat falling on the thermoscope 6 per cent. when equal depths of the selfsame liquid are poured into the cell. Again, by merely changing the parallel sides of the same cell from rock-salt to precisely similar plates of glass, the very same liquid can be shown to intercept a certain quantity of the heat falling on the thermo-pile in the one case, and to augment that quantity in the other—the difference amounting to upwards of 10 per cent. of the total radiation through the empty cell.

The explanation of the foregoing facts may be traced to two main causes. The increased transmission noticed with *films* of the more diathermic liquids chiefly arises from the reduction or abolition of the reflection taking place from the interior surfaces of the walls of the cell, owing to the optical density of the liquid introduced being nearer to the cell-walls' than that of the medium it replaces. But in glass cells of considerable depth, retaining the former explanation, the augmented heat there observed is probably *mainly* due to an effect of the refraction of divergent rays by plane surfaces; this gives rise to a concentration of the beam, which become sensible when accompanied by a great transcalency of the liquid in the cell. In similar cells with rock-salt ends the effect is not observed, probably on account of such cells sifting the beam far less than glass, and thus permitting a higher absorption of the liquid. Nevertheless even with rock-salt cells the causes alluded to must necessarily render, to a certain extent, incorrect the precise absorption hitherto attributed to liquids. These sources of error in determining the true absorption of a liquid or solid can, however, be avoided by employing truly parallel rays; and these are best obtained from the sun.

On the Thermal Resistance of Liquids. *By* FREDERICK GUTHRIE, *F.R.S.E.*

If we wish to get an insight into the specific resistances of the elements and into the law connecting thermal resistance and chemical constitution, we must examine liquids rather than solids, because while the former are essentially homogeneous, the latter are never without structure, and seldom even without texture.

To examine the conductivity of a liquid, it must be either heated from above or cooled from below, in order that convection may be avoided. If the liquid be contained in a vessel, the difference between the conductivities of the liquid itself and of the containing vessel will also introduce convection. In spite of the labours of many able physicists, these difficulties have hindered the prosecution of

this direction of research. The chief numerical results are those obtained by Despretz in his well-known examination of the conductivity of water.

In order to homologate the thermal and electrical phenomena, the term thermal resistance is used in preference to conducting-power or conductivity. The zero of thermal resistance is supposed to exist when two bodies of unequal temperature are in actual contact. If a substance is interposed between the hotter and colder bodies in such a manner that the heat can only pass between them by means of conduction through the interposed substance, then the difference between the quantity of heat which passes when the bodies are in contact and the quantity which passes when the third substance is interposed, is equal to the quantity of heat intercepted by that substance, and is a measure of its resistance.

The instrument used for this purpose is the "Diathermometer;" its construction is as follows:—Two conical brass vessels having thin polished platinum bases are fastened in a stand in such a manner that their axes are in the same vertical straight line; their bases are opposed to one another and are parallel. The apices of both cones are made tubular. The lower cone is screwed into the stand, its neck is fitted with a cork and tube, which dips into water, and which carries a scale. The lower cone and tube form an air-thermometer. The upper cone is moveable vertically, its motion being commanded by a micrometer-screw, which is so divided as to allow of the adjustment of the cone to the 0·005 of a millimetre in vertical direction. The parallel bases of the two cones are adjusted horizontally by a spirit-level and levelling screws in the stand. The upper cone carries a cork, through which pass two tubes, one reaching to 0·5 millimetre of the bottom of the cone, the other opening just below the cork. A current of water may thus be made to flow through the upper cone. A large vessel of water is maintained at any required constant temperature by means of a thermostat. Screens intervene between this vessel and the diathermometer. By means of a siphon and flexible tubes, a current of warm water of known temperature is allowed to pass through the upper cone, commencing at any given moment.

The zero or minimum resistance is found by wetting the bases of the cones with a little mercury and bringing them into contact (the air-film is thus excluded), and passing water of a known temperature for a given time through the upper cone. If the calibre of the tube of the lower cone is known, we can, by observing the linear depression of the column of water in it, calculate the number of heat-units which enter the air of the lower cone by taking into account its capacity, the specific heat of moist air, and the pressure to which the latter is subjected.

If, now, the cones be separated to a known distance and a liquid be introduced between them, it is supported in its position by adhesion and cohesion. When water is passed through the upper cone under the same conditions as in the experiment when the cones were in contact, a less number of units of heat enter the air of the lower cone (as is shown by the smaller amount of depression in the thermometer-tube). This diminution in the number of heat-units is called the resistance of the liquid under the special conditions. As the area of the base of the cones is known, we can calculate the resistance of a rectangular prism of known base and height of a liquid for a given time at a given temperature, and for a given temperature-difference at its two extremities.

The loss of heat suffered by the water in passing from the reservoir was estimated at all temperatures and allowed for. The absolute errors due to the absorbtion and radiation of heat by the brass of the lower cone and to the accumulation of heated air in its upper portion, affect equally the determination of the minimum resistance and that of the interposed liquid; consequently they do not affect the result, which is their difference.

It was shown by measuring the time required to produce any effect on the lower cone, as also by interposing paper disks in the liquid between the cones, that the diathermancy of the liquids at the temperature-differences employed was either nothing or so small as to be negligible.

Special experiments made by colouring the base of the upper cone showed that there was no convection.

The resistance (measured by the number of heat-units arrested in a given time) of a cubic millimetre of about twenty chemically pure liquids was determined

under the conditions—temperature of liquid $=20^\circ{\cdot}17$ C., temperature-difference $=10^\circ$ C.

	Specific resistance.
for water	1·0
„ glycerine	3·8
„ alcohol	9·08
„ amylic alcohol	10·2
„ iodide of amyl	13·27

The column of specific resistance is obtained by dividing the resistances of the other liquids by that of water. Of all liquids, with the exception of mercury, water has the least resistance. Of bodies belonging to the same series, those have the greatest specific resistance which have the greatest molecular complexity.

Experiments were made to determine the rate at which heat of different temperatures travelled through water. Through 3 millimetres of water the first effect of the heat was manifested

in 11″	when the temperature-difference was	5·8
9	„ „ „	15·8
7·6	„ „ „	25·8

It appeared from numerous experiments made in this direction that for the above thickness of water the time for the production of the first effect is diminished about 1″ for every increase of 5° C. in the temperature-difference.

With regard to the time required for the heat to penetrate different thicknesses of water, it was found that the time increases more rapidly than the thickness. Thus for a temperature-difference of 10° C.

	millim.		″
For thickness	1	the time required was	3·4
„ „	3	„ „	10·4
„ „	5	„ „	21·0

The quantities of heat passing through various thicknesses of water in a given time were also determined; and it was found that the resistance was not by any means proportional to the thickness. Thus if the resistance through

	millims.		
	2·5	be represented by the number	63·07,
then	4·5 is	„ „ „	86·24,
and	6·5 „	„ „ „	102·33.

On examining aqueous saline solutions, it was found that their resistances were always greater than that of water, even when the metal in solution was a good conductor, and when the solutions were saturated. From the experiments made in this direction, it is concluded that the solution of a salt in water affects the resistance of the latter only either by displacing some of it and altering its specific heat.

Light.

Certain facts bearing on the Theory of Double Refraction. *By* A. R. Catton.

On Actinometry. *By* Louis Bing.

The writer describes a series of experiments which he made for the purpose of ascertaining the actinic power of light. He shows that the transmission of actinism through a transparent medium varies with different intensities of light in such a manner that instruments constructed for actinometric purposes by means of a transparent medium are practically almost useless. He describes an actinometer which he constructed, and which consists of a single rectangular tube, at one end of which light for measurement is admitted, and to one side of which sensitive

paper is applied. He says, "The principles upon which this instrument is founded are—

(1) "That diffused light, on entering a tube at one end only, varies in intensity within the tube inversely as the squares of the distances from the aperture where light enters.

(2) "That any number of tubes, whatever their magnitudes, contain the same intensity of light if the ratios of their diameters to their lengths are equal, and if we absorb the light that may be reflected from their sides."

He then describes experiments which he made by means of tubes of equal diameter, and of lengths varying by a semidiameter and also with tubes of various magnitudes, the ratios of their diameters to their lengths being equal. By inserting small mica-actinometers at the bases of those tubes, and exposing them thus situated simultaneously to the action of light, the writer gains results which demonstrate the above principles.

Observations on the Atmospheric Lines of the Solar Spectrum in High Latitudes. *By* GEORGE GLADSTONE, *F.C.S., F.R.G.S.*

This paper was explanatory of some diagrams which the author had prepared of the atmospheric lines in the solar spectrum, from observations taken by him during a recent voyage along the north-west coast of Norway. The author stated that what are known by observers of the solar spectrum as the "atmospheric lines" are certain dark lines or bands, which make their appearance under certain conditions, and sometimes even attain a considerable development. These lines, or bands, appear to be due to the presence of some substances in the earth's atmosphere, as they are always most prominent when observing the sun through a long reach of air (as at sunrise or sunset), while they are scarcely visible when the sun is high above the horizon. The observations, of which drawings were exhibited, were taken in the months of June and July last, from the deck of the vessel when off the coast near Stavanger, and at the entrances to the Trondhjem and Namsen fjords; the latter being in 64° 30′ north latitude, in which parallel the sun skirts the horizon for a long time, thus affording very favourable opportunities for observation. It appears that in those regions the red end of the spectrum is very brilliant, so that with the small portable spectroscope he distinctly recognized, on two occasions, the remarkable line A. The observations went to show that the atmospheric band grows in width and intensity as the sun approaches the horizon, and that what in certain states of light, or of the atmosphere, appear to be bands of shade are under other circumstances broken up into lines. Under some conditions the red rays suffer very little diminution of light up to a certain point, when they are suddenly cut off; while under others the obscuration takes place more gradually, and the visible spectrum is much longer. The length of the spectrum, however, in no case affects the width between the respective lines, which remains always the same, but is entirely due to more or less of the extremities being altogether lost in darkness.

On the Value of the Hollow Wedge in examining Absorption Spectra. *By* Dr. J. H. GLADSTONE, *F.R.S.*

The usual way of examining absorption of light by a coloured liquid is to place it in a test-tube behind a narrow slit, and to disperse the line of light by means of a prism. The black or shaded bands due to the absorption may thus be easily noted; but of course they represent only one particular thickness of the liquid. Now the number of these bands often varies, and the extent of them always varies with the depth of the liquid traversed by the light, or, if it be a solution, with the quantity of colouring-matter dissolved. A great advantage is obtained by substituting a hollow glass wedge for the test-tube, and so arranging it before or behind the slit that the narrow line of light examined shall have traversed all thicknesses from, perhaps, two centimetres to nothing. Thus the varying absorption at different depths is seen all at once, and can be easily represented in a diagram which becomes characteristic of the particular substance. The value of this mode of

examining absorption spectra was illustrated by an extreme case—permanganate of potassium; ordinary drawings of the bands were made for four different thicknesses, and the same were expressed in Mr. Sorby's ingenious notation of numerals and dashes and dots, which four figures bore little or no apparent relation to one another, but they were explained by, and included in, the figure obtained when the hollow wedge was employed. Figures were also exhibited showing the absorption of light by cruorine, hæmatine, and cineal in alum, which illustrated in various ways the importance of observing the effect of the varying thicknesses of these substances.

The author suggested the use of the hollow wedge as far back as the Cheltenham Meeting in 1856, and exhibited there, and published afterwards, many diagrams of absorption spectra thus obtained. The reason why other observers have made little use of it was believed to be twofold—it is too simple to please some, requiring no apparatus beyond a common window-shutter, the wedge, and a good prism, while it demands a little more thought in adjustment than the test-tube does, seeing it also bends the ray of light. It may be advantageously placed in front of spectroscopes of the ordinary form; and as the prismatic analysis of transmitted light is becoming a matter of great importance, it seems desirable to adopt the best methods.

Sur une action particulière de la lumière sur les sels d'argent. *By* Professor Morren.

Electricity, Magnetism.

On a further development of the Dynamo-Magneto-Electric Machine. *By* W. Ladd, *F.R.A.S.*

At the Meeting last year the author brought before the Section one of his small dynamo-magneto machines, the first that had been made upon that principle. The author has since constructed a much larger machine, and it may be interesting now to give some particulars respecting it. The object in constructing it was to supply a good electric light for the purpose of lecture demonstrations. It is constructed upon the double armature principle, both armatures being placed end to end, so that their magnetic axes cross each other at right angles. The short armature contains 108 feet of very stout copper wire, and sends its currents into 240 lbs. of copper wire surrounding the electromagnet, exciting a large amount of magnetism in the body of the machine. And as the second armature is also made to revolve between the poles of this electromagnet, a sufficient effect is produced at the two ends of the 312 feet of very stout copper wire (which is wound upon it) to produce a good electric light from the carbon-poles of the regulator. But in order to make that light sufficiently continuous, it is requisite that the armatures should revolve from 1800 to 2000 revolutions per minute; but as the armatures have to be magnetized and demagnetized twice during each revolution, there would be in the latter case 4000 flashes of light per minute. Now it has been shown that every time iron becomes magnetized it is elongated, and again shortened when demagnetized. At every alteration, therefore, of the condition of the iron some small amount of heat must be devolved, and would increase to such an extent that, if unchecked, it would in the course of time be so great as to destroy the insulation of the wire.

The author did not wish it to be inferred that the sole cause of heat is due to the elongation of the iron. Doubtless the electric currents passing through the wire would produce heat; but he believed the quantity produced by that means would be small as compared with that produced by the elongation of the iron itself. The author gave the following reasons for entertaining this opinion. One of these magneto-machines driven by steam-power was lately used in connexion with a large inductorium, and after a few hours it was found that the copper or primary

wire surrounding the core of the coil appeared to be quite cool, while the iron core itself was considerably heated. The author, therefore, mainly assigned the production of the heat to the cause specified. Now to remove this heat he had perforated the two poles of the electromagnet as close as possible to the armatures, and a stream of cold water circulates twice round the machine. This carries off the heat in a most effective manner, and no appreciable detriment in its electrical results occurs.

The quantity of the mixed gases given off per minute had not yet been ascertained; but it is most interesting to notice the continuance of the decomposition of water which takes place for some seconds after all motion in the machine has ceased.

On the Electric Conductivity of Platinum as affected by the Process of Manufacture. By C. W. Siemens, *F.R.S.*

On a Permanent Deflection of the Galvanometer-needle by a rapid series of equal and opposite Induced Currents. By the Hon. J. W. Strutt.

On the Construction of a Galvanometer for the Detection of weak Electric Currents. By F. H. Varley.

The great advance which the labours of Sir William Thomson have made in the means of determining with precision small equivalents of electrodynamic force is sufficiently well known. He has shown the importance and value of using small cores upon which the electromagnetic helices are wound, and the advantage of employing small magnets for indicating and measuring the amount of force flowing through the galvanometer-coil or helix. The small magnet of Sir W. Thomson has a mirror attached to it to reflect a beam of light, so that a small motion of the magnet gives movement to a line of light thrown upon a darkened screen. It has frequently occurred to the author that smaller and lighter magnets could be employed by calling in the aid of microscopic power. Two instruments were constructed with this view. The first consists in suspending by a single filament of silk in the hollow core of the galvanometer-coil a magnet of an inverted spur-form, made of the finest steel wire that can be obtained, and rendering its motion apparent by viewing it through a rectangular prism by means of a microscope, in the eyepiece of which is placed a small scale photographed on glass: the magnet appears as a black bar bisecting the field of view; and as the finest wire obtainable for this purpose appears, when sufficiently magnified, as thick as a scaffold-pole, it is obvious that the slightest motion of the magnet is rendered conspicuous by the image moving to or from over the graduated scale in the eyepiece. The second form is more sensitive than the first: a small magnet made of flat steel polished on one face is suspended in the usual way by a single filament of silk; a small microphotograph of a graduated scale is placed at such a distance from the reflecting surface of the magnet-mirror, that each division equals two minutes of arc as nearly as possible; the image of the scale thus reflected is sent in a line with the optic axis of the microscope; any deflection given to the magnet causes the image of the photographed scale to move across the field of view. The reflecting surface moving doubles the apparent motion, giving the amount due to the angle of incidence, plus that of reflection. The movement of one graduated division being produced by a deflection equal to one minute of arc, if magnified sixty times by the microscope, will render a motion equal to one second of arc apparent and measurable. When desirable, a small scale placed in the eyepiece can be made to give a vernier reading upon the magnified scale. The magnifying-power can be increased where desired, and most minute amounts of motion rendered measurable. The great difficulty of using instruments of such extreme sensibility is due to the interference of extraneous vibration communicated to the small magnets. This, to a great extent, can be overcome by insulating the various parts from vibration by means of antagonizing springs, and preventing the finer vibration from being communicated through the wire itself by

covering the wire with silk or cotton to act as a damper to the more minute vibrations. This instrument being more compact, and not requiring a darkened room set apart for its special use, its application is much more general, whilst it at the same time gives much more minute and sensitive measurements. The instrument can be used in broad day, either in or out of doors, and is applicable to all kinds of galvanometric observations.

On a New Automatic Telegraphic Apparatus. *By* Prof. C. Zenger.

The Morse telegraph requires much cleverness and practice in the telegraphists to deliver despatches quickly, correctly, and easily legible. To avoid mistakes, and to get a more rapid mode of despatching, the author constructed an automatical telegraphic apparatus, intended to make telegraphing with the Morse system quite independent of the telegraphist's cleverness and practice, to procure signs automatically made of as correct a shape as if they were printed. But that is not the only advantage of this apparatus; for it is capable of giving three simple signs instead of only two. These signs are got by pressing down uniformly three levers, the first giving a dot, the second a short line, and the third a nearly three times longer one. The combinations to one, two, and three elements are 3, 9, and 27, in some 38; with the Morse key there are only 2, 4, and 8, in some 14, possible. There are much fewer signs required to obtain all letters and ciphers than with the Morse key, and the despatches become more than one-third shorter than with the common key. But time is also spared; because an able telegraphist may more swiftly telegraph than with the Morse key; for the movement of the three levers is uniform, and may be produced with three fingers put on the keys at the end of each lever. The movement of the levers produces a similar movement of shorter and smaller levers, producing a current of only momentary duration on the first lever, a longer on the second, and three times longer on the third. Whatever may be the velocity of the paper devolving on the Morse writing-apparatus, the relative length of the two lines will not be altered, and becomes quite independent from the hand of the telegraphist. The first lever gives always a dot, or an extremely short line. The author has found by using this key, which is simply placed instead of the Morse key in the circuit without altering anything else in the whole Morse system, that boys and little girls may, after a day's practice, telegraph quite well; and that a clever telegraphist may reduce the space occupied by the telegram about 30 to 33 per cent., and the time spent nearly 40 to 50 per cent., after a short time of practice.

Meteorology.

The Resemblance and Contrasts of the Climates of the Mauritius and Natal. *By* Robert James Mann, *M.D., F.M.S., F.R.A.S., F.R.G.S., Superintendent of Education at Natal, and Acting Special Commissioner of the Natal Government.*

The exact observations on the meteorology of Port Louis, in the island of the Mauritius, made by Professor Meldrum, and printed in the last Report (1867), acquire additional interest and value when compared with observations made at the neighbouring continental station of Natal at the same time. The island of the Mauritius lies in the Indian Ocean between the 20th and 21st parallels of southern latitude, and 1400 miles from the African shore. The colony of Natal lies on the border of the African continent, facing the same ocean between the 29th and 32nd parallels of south latitude. The sun shines approximately with the same inclination and force on both situations; and the prevalent movement of the atmosphere is in the same direction in both, that, namely, of the south-eastern tradewind flowing from the vast open stretches of the Southern Ocean. But in the one case the sun shines, and the ocean-wind blows upon a small island only thirty-five miles across in the widest part, and rising into a tableland 1400 feet high in its centre, with a rampart of jagged peaks about as high again; while in the other

case the sun falls and the wind blows upon the margin of a land that rises rapidly to 6000 feet of elevation, and then stretches away for thousands of miles, getting ever more and more scorched by the intertropical sunshine. A very instructive opportunity is thus afforded for instituting upon a grand scale a careful comparison of the insular and continental conditions and influences. A long and sustained series of observations is required to do full justice to this comparison. A few noteworthy deductions may in the meantime be gathered as "first fruits" of the investigation.

The actual rainfall is not very different for Port Louis, the capital of the Mauritius, and for Maritzburg, the capital of Natal. During a series of eight years it amounted to 241·79 inches, or 20 feet $1\frac{3}{4}$ inch, at the observatory at Maritzburg, and to 324·33 inches, or 27 feet, at the observatory at Port Louis. The mean annual fall for this period was 30·22 inches for Maritzburg, and 40·54 inches at Port Louis. Both stations are placed, so to speak, away from the first impingement of the moist sea-breeze. But the site of observation at Port Louis is less than 50 feet above the sea, and that at Maritzburg is 2095 feet above the sea.

In the Mauritius, in the very limited area restricted in the longest extent to thirty-five miles, there are spots that actually receive four times as much rain as others. Thus in the year 1862, while the fall was 28·3 inches in the north-west, 52·2 inches on the north, and 69 inches in the interior of the island; at the south-east extremity, at an elevation of 960 feet, it was 122·5 inches.

In the colony of Natal the difference between the coast and the capital, more than forty miles inland and more than 2000 feet high, is only as 2 to 1. In one case of careful comparison, when the fall at the Port of Durban was 22·59 inches, the fall at Maritzburg was 11·75 inches.

In the Mauritius there is a considerable difference in the amount of rainfall in different years. In a series of eight years the least yearly rainfall at Port Louis was 20·5 inches, and the greatest 68·7 inches. In a similar range of eight years the least annual fall at Maritzburg was 22·4 inches, and the greatest annual fall 37·3 inches.

In the Mauritius the rainfall distinctly increases with elevation up to nearly 1000 feet.

In Natal the greatest fall certainly takes place on the windward side of the land, that is, on or near the coast; and it then *diminishes* rapidly with elevation.

There are no observations yet available to give the fall for the range of country intermediate between Durban and Maritzburg; but there certainly is no spot where the rainfall materially exceeds that of the district near to the sea itself. The large tract of heated land along which the sea-breeze has to rise, seems at once to give the atmosphere more vapour-sustaining power, until the ascent becomes sufficiently energetic and turbulent to give rise to the periodically recurring thunder-storm.

The seasonal distribution of the rainfall is remarkably regular on the border of the African continent, that is, at Natal. There is a distinct division of the year into a wet season and a dry one; and the wet season most beneficently corresponds with the summer half of the year. Four-fifths of the rain in Natal falls between the beginning of October and the end of March, and one-fifth between the beginning of April and the end of September. The midwinter months of June and July are almost dry. In the two months before and two months after these, the rainfall is $1\frac{1}{5}$ inch for each month. In the six summer months it averages $4\frac{1}{5}$ inch for each month. In the Mauritius 58 per cent. of the rain falls between December and March, and 42 per cent. during the other eight months. In Natal December is the wettest month of the year; in the Mauritius February is the wettest month. The rainfall in the Mauritius is more concentered in the middle of the summer than it is in Natal, and is occasionally raised to a great extent in February by the occurrence of hurricanes.

In the Mauritius June and July are dry months, as in Natal; but there is there a sort of second dry season after August. October and November are dry in the Mauritius, but distinctly and emphatically wet in Natal.

In both situations the general tendency is to increased rainfall with increase of temperature, and therefore of sea evaporation, which mounts to the highest point

in February. This agency, however, is somewhat anticipated, and over-ridden, in Natal, by the establishment of frequent periodic thunder-storms, which begin in October.

The thunder-storm is a *very much* more frequent phenomenon in Natal than in the Mauritius. During a series of seven years lightning was seen, or thunder heard, on 186 days at the Mauritius. In a series of eight years lightning was seen, or thunder heard, on 635 days in Maritzburg. The average number of days of electrical disturbance in any year is 26 for the insular position of the Mauritius, and 79 for the continental position of Natal. In the Mauritius lightning is never seen in the months of June, July, September, and October; and it is very rarely seen in the month of August.

Insularity of position thus causes greater diversity and irregularity, and more widely separated extremes in the deposit of rain, both so far as different seasons of the same year and different years of a lengthened series are concerned. But it exerts exactly the opposite influence in regard to temperature. The mean temperature of the Mauritius is considerably above the mean temperature of Natal; but higher and lower temperatures are experienced in Natal than in the Mauritius. The great ocean serves as a ready and exhaustless *supply* of rain, but as a reserve and *reservoir* of heat.

The mean annual temperature of Port Louis is 77°·1. The mean annual temperature of the sea-coast of Natal (Durban) is 68°·2, and of Maritzburg, 2095 feet above the sea, 64°·7.

In a series of six years the highest annual mean at Port Louis was 78°·2, and the lowest 77°·0. The highest at Maritzburg was 65°·80, and the lowest 64°·27.

The mean temperatures of the several months of the year, derived from a series of seven years, were, for the two stations,—

	Port Louis.	Maritzburg.		Port Louis.	Maritzburg.
January	82·30	71·4	July	72·52	55·2
February	82·16	71·8	August	72·83	59·7
March	81·53	69·7	September	74·14	65·1
April	80·63	64·8	October	75·78	66·6
May	77·12	59·3	November	79·22	67·1
June	74·00	55·2	December	81·44	70·4

The range of monthly mean temperature is 9°·78 at Port Louis, and 16°·6 at Maritzburg.

Comparison of Temperature of Port Louis and Maritzburg during a series of eight years.

	Highest temperature.	Lowest temperature.	Extreme range of temperature.	Largest daily range of temperature.	Largest monthly range of temperature.
Port Louis.	90°·0	62°·8	27°·2	13°·0	18°
Maritzburg	97·6	29·0	68·6	43·0	27

The extremes in Natal are much less than they would otherwise be, on account of the summer being the period of predominant cloud and rainfall, and the winter the period of predominant sunshine. The air-temperature was only below the freezing-point at Maritzburg five times during eight years.

The annual and diurnal oscillations of the barometer are well marked at both the Mauritius and Natal. The mean pressure of the atmosphere falls from August to February, and rises from February to August. The daily pressure sinks from

nine in the morning until three in the afternoon, and rises from three in the afternoon until nine in the evening. The diurnal oscillation amounts to 7-hundredths of an inch at Port Louis, and to 78-thousandths of an inch at Maritzburg. During a period of eight years there were only 217 days on which the diurnal oscillation was not distinctly marked at Maritzburg.

The average yearly range of the barometer is—

Port Louis 0·914 inch. Maritzburg 0·991 inch.

The highest pressure at

Port Louis 30·400 inches. Maritzburg 28·714 inches.

The lowest pressure at

Port Louis 29·009 inches. Maritzburg 27·215 inches.

(The height above the sea of the observing station at Maritzburg being 2095·674 feet.)

The extreme range of atmospheric pressure during a period of seven years was

At Port Louis 1·391 inch. Maritzburg 1·259 inch.

The greater range at the Mauritius is obviously due to the occurrence of hurricanes there, which do not extend to Natal.

The pressure of the atmosphere reduced to the temperature of 32° and to the sea-level, derived from a period of eight years, is for

	inches.
Port Louis, Mauritius..........	30·056
Maritzburg, Natal	29·977

The diurnal and annual oscillations of the barometer are obviously due to the rarefying power of day sunshine and summer sunshine. But in Natal there are, in addition to these, oscillations averaging about 10 days, for the most part due to the alternate predominance of the low polar or higher equatorial current of the air. There were in Natal 291 well-marked oscillations of this class in a period of eight years. When the south-eastern surface-current (trade-wind) prevails over the higher north-west compensatory set of the atmosphere, the mercury of the barometer goes up; when the upper north-west current predominates, the mercury goes down. The thunder-storm rains occur with the troughs of these oscillations, and the sea-gales and rains with their crests. Occasionally the upper more rarefied current entirely displaces the surface-current for a brief period at Maritzburg, and sweeps upon the ground as a strong hot dry wind. This Natalian sirocco blows at Maritzburg about twenty-five times in the year. It occurs most frequently in the month of September, in which month it may be looked for five times. It becomes more frequent during the two months preceding September, and less frequent in the two months following September, thus showing that the alternate sway of the great antagonistic air-currents is really a seasonal phenomenon due to the march of solar influence to and fro over the wide stretch of African land. These hot winds do not reach the actual surface of the sea, and are therefore not felt in full development, either on the Natal coast or at the Mauritius. They are, however, unquestionably connected with the north-west gales of the South Atlantic. The gale of the 17th of May, which wrecked the mail steamship 'Athens' in Table Bay, was an oscillation eleven days long, bursting as a hot wind in the crisis of the gale and barometric depression at Maritzburg.

Abstract of Meteorological Observations made at Pietermaritzburg, Natal.
By Dr. Mann, *F.R.A.S., F.R.G.S., F.M.S.*

Latitude of observatory	29° 36′ 13″ S.
Longitude of observatory	30 1 34·5 E.

Height above the Custom House, near the sea-level at Durban, from a mean of eighty barometric observations by standard and compared instruments,

2095·674 feet.

Barometer Observations, reduced and corrected, from Standard Instruments.

	Mean barometric pressure of 8 years.		Mean barometric pressure of 8 years.
	in.		in.
Mean height	27·891	Greatest range of eight years.	1·259
Highest reading	28·474	Mean height at 9 A.M.	27·958
Lowest reading	27·215	Mean height at 3 P.M.	27·883
Yearly range	·991	Mean height at 9 P.M.	27·961
Highest in last eight years	28·474	Mean daily range	·078
Lowest in last eight years	27·215		

Thermometer Observations.

	Mean temperature of 8 years.
Mean temperature of year	64°·71 Fahr.
Mean highest temperature	95·60
Mean lowest temperature	33·10
Mean widest range of temperature	62·50

	Mean temperature of 8 years.	Highest temperature in 8 years.	Mean highest temperature of 8 years.	Lowest temperature in 8 years.	Mean lowest temperature in 8 years.
January	71°·4	93°·0	90°·3	51°·8	57°·8
February	71·8	97·1	91·0	55·8	58·4
March	69·7	92·8	87·5	42·0	52·2
April	64·8	89·5	84·6	40·2	46·3
May	59·3	85·2	79·4	35·4	39·6
June	55·2	78·2	74·7	32·0	35·8
July	55·2	82·2	79·1	29·0	34·2
August	59·7	89·8	84·2	34·8	38·7
September	65·1	95·4	92·1	38·0	43·5
October	66·6	96·0	90·7	45·2	48·7
November	67·1	97·2	91·0	45·2	50·9
December	70·4	97·6	92·3	52·2	56·4

During the year 1865 there were 12 days on which the temperature rose to 90°, and 49 to 84°; 81 nights on which the temperature fell to 50°, and 211 to 60°; 115 days on which the temperature did not exceed 70°, and 8 that did not rise to 60°; 7 nights on which the temperature did not fall below 70°, 23 that fell below 40°, and 2 that fell to 36°.

Rainfall.

	Greatest rainfall in 8 years.	Mean rainfall for 8 years.		Greatest rainfall in 8 years.	Mean rainfall for 8 years.
	in.	in.		in.	in.
January	6·63	3·92	July	0·74	0·23
February....	7·59	4·41	August	3·44	1·14
March	5·94	3·29	September ..	3·11	1·32
April	2·02	1·44	October	7·21	3·60
May........	2·94	0·95	November ..	8·95	4·58
June	1·28	0·26	December ..	6·23	5·04

Total rainfall for the years		Total rainfall for the years	
	in.		in.
1858	27·42	1863	34·66
1859	28·40	1864	37·31
1860	30·60	1865	31·08
1861	22·41	Mean rainfall for the year in 8 years	30·11
1862	29·97		

The mean number of days (for 8 years) on which rain fell in January were 16, February 14, March 13, April 9, May 3, June 1, July 2, August 5, September 8, October 17, November 17, December 18.

Average number of days on which rain fell in each year, for eight years.		123
Average of days on which rain fell for each of the two dry months, June and July		$3\frac{1}{2}$
Average of days on which rain fell for each of the four intermediate months, April, May, August, and September		$8\frac{3}{4}$
Average of days on which rain fell for each of the six wet months		$15\frac{1}{2}$
Rainfall for the two dry months	(inches)	0·49
Monthly average fall for the two dry months	”	0·24
Rainfall for four intermediate months	”	4·85
Monthly average fall for four intermediate months	”	1·21
Rainfall for six wet months	”	24·84
Monthly average fall for six wet months	”	4·14

Mean Degree of Moisture of 8 years.

	Mean at 9 A.M.	Mean at 3 P.M.	Mean at 9 P.M.
January	71·3°	67·8°	84·3°
February	74·4	67·8	84·8
March	74·5	63·9	85·1
April	74·9	60·9	83·9
May	74·1	54·4	81·1
June	72·3	49·2	76·0
July	68·3	45·9	73·9
August	65·6	49·1	74·9
September......	65·7	55·5	78·9
October	71·2	67·0	83·9
November	70·9	68·9	83·5
December	71·5	71·1	84·8

Mean humidity of air at 9 A.M. for eight years	......	71·2
" " 3 " "	......	60·1
" " 9 P.M. "	......	81·2
" " for eight years	....	70·8

Thunderstorms.			Hot winds.		
	Days on which a thunderstorm occurred.			Days on which strong hot winds occurred.	
	Greatest number in 8 years.	Mean for 8 years.		Greatest number in 8 years.	Mean for 8 years.
January	12	7·9	January	3	1·3
February ..	10	6·6	February ..	3	1·2
March......	9	5·2	March	4	0·7
April	7	2·9	April	3	0·8
May	6	1·5	May	3	1·2
June	1	0·2	June	3	0·8
July	2	0·8	July	4	2·3
August	3	1·1	August	7	3·2
September ..	10	3·6	September ..	8	5·1
October	14	6·2	October	8	4·2
November ..	12	7·3	November ..	4	3·0
December ..	11	8·1	December ..	5	1·7
Average for 8 years ..51			Average for 8 years ..25		

Entire number of storms in six wet months 40*, and in six dry months 19. Days of lightning without thunder, that is, on which there are storms just beyond ten miles, 12.

Sunshine and cloud.—Number of days of unbroken sunshine in six wet months 10, in six dry months 49. Number of days of unbroken cloud in six wet months 44, in six dry months 21.

Number of days in year of unbroken sunshine 59, of unbroken cloud 65, of mingled sunshine and cloud 241.

Wind.—The wind was blowing during the year, at nine in the morning, 238 times on shore—E., S.E., S. (cool direction); 77 times off shore—W., N.W., N. (warm direction); 50 times along shore—N.E., S.W.

At three in the afternoon 296 times on shore, 28 times off shore, 41 times along shore.

At nine in the evening, 286 times on shore, 40 times off shore, 39 times along shore.

During 1095 evenly distributed observations the wind was blowing 820 times from the cool quarter (that is, in the direction of the combined trade and monsoon), and 145 times in the opposite direction, that is, of the higher compensatory current.

The predominant or natural air-current was only disturbed 69 days in the afternoon, 79 days in the evening, and 127 days in the morning.

* Each unit means one, or more storms, present on a single day. Several storms on the same day are entered as 1.

Comparison of Maritzburg and Durban Temperatures during last four months of the year 1865.

Mean taken from simultaneous observations at the two places at nine, three, and nine.

Months.	Maritzburg.	Durban.
	°	°
September	64·6	69·3
October	70·0	72·5
November	68·6	71·7
December	71·4	78·4

Mean temperature of four months at Maritzburg 68°·6, and at Durban 72°·1. Mean temperature of Durban 3°·5 higher than mean temperature of Maritzburg.

Comparison of Rainfall at Maritzburg and Durban for last six months of the year 1865.

Months.	Maritzburg.	Durban.
	in.	in.
July	0·10	0·48
August	1·26	3·82
September	2·44	7·41
October	0·93	0·59
November	3·18	6·07
December	3·84	4·22
Total	11·75	22·59

Barometric Pressure at Durban, near the sea-level, during the last four months of the year.

Height of standard barometer, corrected for capillarity and capacity, but not corrected for temperature.

Months.	9 A.M.	3 P.M.	9 P.M.
	in.	in.	in.
September	30·212	30·134	30·178
October	30·107	30·033	30·010
November	30·020	29·911	30·012
December	30·114	30·053	30·805

Mean height for the four months at 9 A.M. 30·113, at 3 P.M. 30·032, at 9 P.M. 30·071. Mean height of barometer at Durban, near the sea-level, for four months 30·072.

On Synoptic Weather-Charts of the Indian Ocean. *By* Charles Meldrum, *M.A.*

The object of these charts, which are now being prepared, is to show the state of the winds, weather, and sea, and the pressure and temperature of the air, at noon on each day, for a period of one or more years, over the Indian Ocean, between the meridians of Greenwich and 120° E., and the parallels of 23° N. and 45° S.

As stated in a paper communicated to the Section last year, the Meteorological Society of Mauritius has, since the 1st January 1853, been tabulating the observations recorded in the log-books of vessels visiting the harbour of Port Louis, so as to form a journal containing information with respect to wind, cloud, rain, fog, lightning, &c., and the state of the sea, for each day and, as far as possible, for each hour; and it is from that journal that the materials for constructing the charts are mainly derived. Up to the present time, about 215,000 days' observations, each comprising several observations taken in the course of the twenty-four hours, have been tabulated, and a separate collection has been made of numerous details relating to the hurricanes which have occurred during the same period. Since 1859 the annual number of observations has considerably increased, and for several years there is a daily average of from 70 to 80 days' observations, or, in other words, of 70 to 80 vessels on board each of which various observations were taken daily.

The importance of synoptic weather-charts, as a means of studying meteorological phenomena, had induced the author to attempt to bring out a series of such charts about twelve years ago. The observations collected for March 1853, together with several charts, were published in 1856, and daily charts for other months prepared; but for various reasons, of which the fewness of the observations was one, the daily average being only 30, the work was abandoned. Subsequently, several hundreds of synoptic charts were constructed for periods for which the observations were more numerous, and it was now proposed to issue those for 1861. The mean daily number of observations for that year, recorded in Mauritius, was 70, and as the author was to be favoured with a copy of those in the Office of the Meteorological Committee of the Royal Society, the total daily average, including the observations taken at the Indian and other Observatories, would fall little short of 100.

In order to render the charts synchronous, the observations are, as far as practicable, referred to the meridian of 60° E., which divides the charts into two equal parts, and is taken to represent noon. Generally this is easily accomplished with respect to the winds and weather, which are frequently observed in the course of each day; the chief difficulty being in applying corrections for the positions of the vessels at local noon, when they happen to be at considerable distances from 60° E., and to be going at a rapid rate; but the correction seldom amounts to 40 miles, and is often so small that it may be omitted. There is much greater difficulty with regard to the pressure and temperature of the air. In ordinary weather these are observed on board ship only at noon. Hence the isobaric and isothermal curves, as given in the charts, represent the pressures and temperatures at local noon, and not at the same moment of absolute time; for it is impossible to apply corrections which would make the observations synchronous. Noon, however, happens to be nearly the hour when the barometer is at its mean daily height; and therefore in usual weather the isobars for local noon probably represent with tolerable accuracy the mean pressure for the day at the localities over which they pass. When the weather is stormy, and the barometer is falling, observations are taken hourly or oftener; so that corrections may be applied.

After describing the manner in which the observations were reduced and the results delineated graphically, the author exhibited specimens of the charts, and called attention to the connexion which apparently subsisted between the several phenomena, particularly the isobaric curves and the directions of the wind, and ventured to think that a series of such charts would be of some value. The Mauritius observations, with those belonging to the Board of Trade, were alone sufficient for constructing ten years' daily charts of about ninety observations each.

As a method of investigating weather phenomena and discovering atmospheric laws, there could, he thought, be little doubt that synoptic or synchronous charts were more important than average charts, in which various disturbances, deviations, and even periodicities were entirely masked. He would go further, and say that a series of synoptic charts for a particular ocean would be of more service to the practical navigator than average charts, not only in giving him an insight into weather sequences, but in affording more reliable information as to the winds and weather likely to be experienced in a certain locality at a certain time; that, for example, half a dozen observations of the winds which actually occurred

within a five-degree square, on each of two or three days of normal weather, would be a better guide to the seaman than a wind-rose purporting to show the proportion of different winds often from a small number of observations made unconditionally in different years and seasons and in all kinds of weather. At all events, without undervaluing the method of averages and the importance of constants, it might, he believed, be said that it was to the system of comparing observations taken simultaneously over extensive portions of the earth's surface that meteorology was likely to owe most progress for some time to come. Considering the interests at stake, the sooner, he thought, this system was generally adopted the better. Who could doubt that if we had had charts showing the directions and force of the wind, the isobars, &c. over the North Atlantic, the continent of Europe, and the British Islands, at a certain hour on each day, even for the last twelve months, we should be in a position to solve, wholly or partly, questions of great importance to science and navigation?

On Storm-Warnings in Mauritius. By Charles Meldrum, *M.A.*

By charting the winds and weather over the Indian Ocean for noon of each day during several years, and examining the connexions between the changes which took place at Mauritius and at various distances on all sides of it, the author ascertained that no heavy gale occurred within a distance of at least 1500 miles the existence of which was not indicated in the island by the barometer, winds, and weather. When signs of a hurricane at sea appeared at the Observatory notices were published in the daily newspapers, stating where the storm was raging, and in what direction it was travelling. The author explained in detail the grounds upon which these warnings were issued, showing that there were three classes of gales in the Indian Ocean south of the equator, and that each of them affected the weather at Mauritius. As a general rule, the barometer never fell one-tenth of an inch below its mean height for the season except when a gale existed at a distance, and the character of the gale, and its bearing and course were determined by the direction and veering of the wind, the barometer, and state of the clouds and weather. These results afforded the hope that similar rules might be successfully used on board ship in the Indian Ocean. In conclusion, the author expressed the opinion that the existence and course of storms in extra-tropical countries would yet be known at a distant station with far more certainty and precision than at present, for the winds in temperate climates, though more variable, were just as subject to law as those within the tropics.

On some Meteorological Results obtained in the Observatory at Rome. By Padre Secchi.

The author began by stating the necessity that the climate of each observatory should be accurately known. He then expounded how he has calculated the temperature for every day of the year by simply taking the means for forty years of the same day of the year. The result was, that even after so long a term of observations, no regular curve was obtained, not even if it was tried to smooth the irregularities by Mr. Bloxam's method. The author, however, has not used this method except for five days, and only to ascertain that the irregularities did not disappear. The comparison of the normal curve obtained for Rome with those which are given for Paris, Berlin, Greenwich, Prague, Vienna, Bologna, show evidently that these irregularities are not due to chance, since they appear also in many other places, but that they are certainly an effect of the reaction of the sun's heat on some particular places of the earth, combined with the law of the successive propagation of storms. The law of this propagation has been studied, and it was found that the storms propagate from the British Islands to Italy in about two days; and the author pointed out the station of Nairn, in Scotland, as the best station which may indicate by telegraphic despatch the future state of weather in Rome. The author afterwards entered into a full explanation of the relation existing between the magnetical and meteorological perturbations, and he stated that in Rome these perturbations are signals of approaching storms. He attempted to explain them by the electrical currents which accompany the meteorolo-

gical changes. He said that this theory is not commonly admitted by English observers, because, perhaps, there is not in this country so powerful a display of electricity as on the continent, and perhaps it has not been sufficiently investigated how far this relation goes. Whatever may be the cause of this difference (if it is true), it is certainly necessary that it should be thoroughly studied, to which purpose a magnetical observatory with photographic records would be very useful, if it could be established also in Rome. The author, however, did not attribute all magnetical variations to meteorological changes. He stated that, from the observations made in Rome both on the sun's spots and magnetical instruments, a splendid confirmation was obtained of the minimum of solar spots, combined with the minimum of variation in magnetical elements, both in respect to regular and irregular oscillations. The author concluded by insisting on the great advantage which accrued to the art of navigation in the Italian ports from telegraphic indications of English meteorological states; and he noticed that a regular service is already in activity between Rome and the port of Civita Vecchia for this purpose, to the great satisfaction of the sailors.

CHEMISTRY.

Address by Professor E. Frankland, *F.R.S., President of the Section.*

At these annual reunions of those interested in Chemical science, it is usual for the President of this Section to take a rapid survey of the progress of Chemistry during the past year, and in conformity with that custom, it now devolves upon me to bring under your notice some matters which may, perhaps, with advantage arrest our attention for a few moments before we proceed to the actual business of the Section.

It may be safely asserted that at no previous Meeting of the British Association has there been evinced such an amount of interest in experimental science, and especially in Chemistry, as that which pervades the length and breadth of this country. The international display of manufactures last year in Paris produced upon British visitors an impression which, if not quite unanimous in its kind, was almost entirely so, as regards the resulting conviction, viz. that in the education of the youth of this country scientific instruction is neglected, or systematically excluded, to an extent which finds no approach to a parallel in any other great European nation. There are many, and I confess to being one of them, who consider that even now our trade and manufactures are suffering to a very marked extent from this grave defect in our national education. It is thought by some that ignorance, on the part of managers and workmen, of the scientific truths upon which most manufacturing processes depend, has not yet begun palpably to tell upon our manufacturing prosperity; but, whatever difference of opinion there may be as to our present industrial position amongst nations, all agree in this, that without the extensive introduction of thorough scientific training into the education of those destined for industrial pursuits, we can no longer continue to maintain that preeminence in manufactures which we have now so long enjoyed.

The great science schools of the continent have no parallels in this country. The discouraging way in which scientific studies are being introduced into our older universities, the lack of the necessary funds for the proper endowment of professorships, and for the provision of suitable buildings and apparatus in our modern institutions, and the insignificance of the rewards offered to successful students in science, have naturally operated most injuriously upon the extension of chemical culture. Whilst in Heidelberg, Zürich, Bonn, Berlin, Leipzig, and Carlsruhe magnificent edifices have been raised, replete with all the newest contrivances for facilitating the prosecution of chemical studies, we are here still compelled to give instruction and conduct research in small and inconvenient buildings utterly inadequate to the requirements of modern chemistry. The large sums spent by the governments of Germany and Switzerland upon these establishments suf-

ficiently testify to their opinion of the national value of chemistry in education. The laboratory at Zürich cost £14,000, that of Bonn £18,450, the one now nearly completed in Leipzig will cost £12,120, whilst the estimates for the Berlin laboratory, with its 74 rooms, amount to no less than £47,715.

Such being the comparatively discouraging circumstances under which chemistry is prosecuted in this country, it is not surprising that neither the number of investigators, nor the amount of new facts added to our knowledge during a given time will bear a favourable comparison with the chemical activity of other and more favoured nations. In the year 1866, 1273 papers were published by 805 chemists, being at the average rate of 1·58 paper for each investigator. Of these, Germany contributed 445 authors and 777 papers, or 1·75 paper to each author; France 170 authors and 245 papers, or 1·44 paper to each author; the United Kingdom 97 authors and 127 papers, or 1·31 paper to each author; whilst other countries furnished 93 authors and 124 papers, or 1·33 paper to each author. Our case is even worse than it appears to be from these figures; for a considerable proportion of the papers contributed by the United Kingdom were the work of chemists born and educated in Germany, but resident in this country. I am not aware how far a like comparison as regards activity in research obtains in other sciences; but if the United Kingdom takes a similar position in them, it is nothing less than a national disgrace that a country, which perhaps more than any other, owes its greatness to the discoveries of science, should do so little towards the extension of scientific research.

Fortunately, however, this national apathy has not been shared by individual chemists, and the year has not passed without several important additions to our knowledge. The Master of the Mint has continued his remarkable researches on the occlusion of gases by metals. The extraordinary property possessed by some of the metals, but especially by palladium, of absorbing large volumes of certain gases, is one of the most interesting of modern observations, and can scarcely fail to throw light upon that obscure class of phenomena, occupying the border land between the recognized domains of chemical and cohesive attraction.

Many cosmical changes, such as the variation of animal and vegetable species, move too slowly for our study. On the other hand, the sequence of transformations in chemical phenomena has generally been deemed too rapid to permit of the observation of anything but the final result. Harcourt and Esson, however, have shown that this phase of chemical action can be studied with very interesting results; in the cases of the action of oxalic acid upon permanganic acid, and of hydriodic acid upon hydroxyl, they have arrived at the following important conclusions:—

1. The rate at which a chemical change proceeds is constant under constant conditions, and independent of the time that has elapsed since the change commenced.

2. When any substance is undergoing a chemical change, of which no condition varies, excepting the diminution of the changing substance, the amount of change occurring at any moment is directly proportional to the quantity of the substance.

3. When two or more substances act one upon another, the amount of action at any moment is directly proportional to the quantity of each of the substances.

4. When the rate of any chemical change is affected by the presence of a substance, which itself takes no part in the change, the acceleration or retardation produced is directly proportional to the quantity of the substance.

5. The relation between the rate of a chemical change occurring in a solution and the temperature of the solution is such, that for every additional degree the number expressing the rate is to be multiplied by a constant quantity.

In mineral chemistry, an active Member of this Section has done excellent service by the careful reinvestigation of the compounds of vanadium. Roscoe's researches have led to the discovery that vanadium does not, as was previously believed, belong to the sulphur group of elements, but to the nitrogen group. The vanadic chloride, of anomalous vapour-density, is now shown to be a normal oxychloride. The isolation of vanadium will be looked forward to with much interest, since the atomic weight of this element assigns to it a position intermediate between phosphorus and arsenic.

Chemists had long regarded with regret the labour expended by meteorologists,

on observations made with the intention of estimating ozone in the atmosphere, in the absence of any conclusive evidence of the existence of this substance in the air. It is therefore highly satisfactory that Andrews, to whom we were already so much indebted for our knowledge of the properties of ozone, has at length proved, that the reaction exhibited by ozone test-papers, at a distance from towns, is in reality due to ozone. Thus the numerous observations, extending over so many years, now attain a value which they did not before possess.

The synthetical and constitutional departments of Organic Chemistry have received important additions from the discoverer of the first aniline colour. In pursuing his interesting researches on the salicylic series, Perkin has succeeded in artificially producing coumarin—the odoriferous principle of the sweet-scented Woodruff and Tonquin bean—besides a number of homologues of this substance. To the same Chemist we are also indebted for a theoretical paper of great importance, on the probable difference in the value of the four bonds of carbon—a subject which, in its bearings upon isomerism, has long claimed, though it has never received, the earnest attention of Chemists.

Perkin and Duppa have submitted the glyoxylic acid, originally obtained by them from dibromacetic acid, to a searching constitutional investigation, which has led them to the conclusion that this acid is identical with the one obtained by Debus from the slow oxidation of alcohol; thus establishing the fact that two semi-molecules of hydroxyl can unite with one and the same atom of carbon—a kind of combination the possibility of which had been disputed, although an analogous compound of hydrosulphyl is well known.

Maxwell Simpson, another of the most active and successful workers in this branch of Organic Chemistry, has continued his researches on the constitution of succinic acid, and on the direct transformation of chloriodide of ethylene into glycol.

To general Organic Chemistry important contributions have been made by Stenhouse on chloranil, and by Griess on the action of cyanogen upon amido-acids.

Physiological Chemistry has received a new impulse from the highly instructive experiments of Crum Brown and Fraser on the connexion between chemical constitution and physiological action. It had been shown by Bunsen that cacodylic acid, though readily soluble in water, and containing 54 per cent. of arsenic, produced, when administered to animals, no appreciable poisonous effect, whilst Landolt found that the poisonous properties of antimony disappeared in the salts of tetramethylstibonium. Messrs. Crum Brown and Fraser have studied the change in physiological action produced by the addition of methylic iodide to the natural alkaloids, strychnine, brucine, thebaine, codeine, morphine, and nicotine, and they show conclusively that the physiological action of these poisons is both greatly diminished in degree and completely changed in character. Their experiments also lead them to the singularly remarkable and important conclusion, that when a nitrile base possesses a strychnine-like action, the salts of the corresponding ammonium bases have an action identical with that of the curare poison. It is well known that curare and strychnine are derived from plants belonging to the same *genus*; and it is, therefore, interesting to observe such a relationship.

Again, the experiments of Dr. Arthur Gamgee on the action of nitrites upon blood afford a striking illustration of the successful application of the most delicate processes of chemical analysis to physiological research.

I cannot close this brief and very imperfect summary of British chemical investigation during the past year without congratulating the Section on the completion of that most valuable addition to the literature of the science—Watt's Dictionary of Chemistry. The extent, completeness, unity of design, and general accuracy of this great work reflect the highest credit upon its talented editor, who has conferred a boon upon his colleagues for which they can never sufficiently thank him.

The statistics illustrative of comparative chemical activity in this country and elsewhere warn me not to attempt, in these necessarily brief remarks, any analysis of foreign research. I cannot, however, avoid alluding to one or two out of the many foreign achievements of the past year.

In Mineral Chemistry, the application of the doctrines of atomicity to the formulation of natural minerals, in the new edition of Dana's great work, constitutes an epoch in mineralogy which can scarcely fail to produce in that science results as important as those which this doctrine has already achieved in chemistry proper.

In Organic Chemistry, Hofmann's discovery of a new series of cyanogen compounds imparts a new stimulus to researches on isomerism, and will long remain one of the great landmarks in organic investigation.

In Kolbe's laboratory the yearly harvest of synthetical discoveries has not failed. The direct conversion of carbonic anhydride into oxalic acid by Dr. Drechsel, and of ammonic carbonate into urea by Basaroff, are amongst the most brilliant achievements yet recorded in this branch of research.

The artificial production of neurine by Wurtz illustrates strikingly the precision with which the results of chemical action can now be predicted. The atomic theory of Dalton, developed as it has been by the doctrine of atomicity, is rapidly assuming, for chemical phenomena, the position which the theory of gravitation occupies in cosmical science.

After a long period of indecision and confusion, as regards the atomic weights of a majority of the elements, it is gratifying to find that, at the present moment, an almost complete unanimity, prevails amongst chemical teachers. Out of upwards of 900 papers, worked in all parts of the United Kingdom, at a recent examination connected with the Science and Art Department, the old atomic weights were employed in less than twenty cases. It is much to be regretted that this unanimity does not extend to notation and nomenclature; as regards the latter, a much greater uniformity prevails in France and Germany than in this country, and it is greatly to be desired that efforts should be made to bring about a better understanding on the subject. To the student a uniformly recognized nomenclature is perhaps of more importance than a generally accepted notation. For the present, the realization of the latter appears to be impossible; but by a little mutual concession on the part of teachers, and especially of authors, there would be good hope of soon accomplishing the former.

On the Chemical Composition of the Great Cannon of Muhammed II., recently presented by the Sultan Abdul Aziz Khan *to the British Government. By* F. A. Abel, *F.R.S.*

This interesting example of heavy ordnance of early date, which has recently been added to the Museum of Artillery at Woolwich, is one of the large bombards which have, for about four centuries, occupied positions in the batteries on the Dardanelles.

The gun consists of two parts, which are screwed together: each part weighs about 9 tons, the total weight of the piece being 18 tons 14 cwt. 3 qrs. Its external form is cylindrical, the muzzle being as large as the breech; each end of either separate part carries a projecting moulding which is divided by cross-bars into recesses. The object of these was not simply ornamental; the recesses obviously serve the purpose of the holes in a capstan-head, being required to give purchase to the levers employed in screwing the two parts together, and in moving the gun. Each piece has some simple moulding-ornamentation at the ends, and the external surfaces are subdivided by rings or mouldings about 14 inches apart. The total length of the gun is 17 feet, the diameter of the powder-chamber is 10 inches, that of the bore is 25 inches. The two screws which join the pieces together, and are 28 inches in diameter, are skilfully cast. Some spherical stone shot received with the gun weigh 670 lbs.; the charge of powder required being $49\frac{1}{2}$ lbs.

For the purpose of analysis, specimens of the alloy were detached from different parts of the gun; these were found to vary considerably both in hardness and composition. Samples marked I. and IV. proved to be almost identical with the best descriptions of gun-metal of recent manufacture, whilst those in which the amount of tin was larger, exhibited specks of white alloy irregularly dispersed through the masses. On the other hand, Nos. III., IIIa., and V. contain higher

proportions of copper than have been found in any other specimens of ancient gun-metal, the results of which have been published.

The results of analysis were as follows:—

From the Moulding at Rear-end of the Breech-piece.

	I.	Ia. (In close proximity to I.)
Copper	92·00	89·58
Tin	7·95	10·15

From the Moulding at Front-end of the Breech-piece.

	II. Top of moulding.	III. Side of moulding.	IIIa.
Copper	90·57	93·70	94·22
Tin	9·75	6·23	5·60

From the Moulding at Rear-end of the Chase.

	IV.
Copper	91·22
Tin	8·49

From the Moulding at the Muzzle.

	V.
Copper	95·20
Tin	4·71

The great guns of the Dardanelles appear to have been produced from the metal of small cannon; and there is little doubt that no approach to a uniformity of mixture of the alloys composing those cannon could be attained with the crude means at command for melting the metal. It is, however, interesting to note that, in the seven specimens taken from the great gun at Woolwich which have been analysed, only traces of other metals than copper and tin have been discovered. Lead and iron were detected in minute quantities, and traces of antimony and arsenic were also discovered; but a careful examination of the specimens for gold, silver, and zinc failed to furnish any indication of the presence of these metals.

Note on Löwig's Researches on the Action of Sodium Amalgam on Oxalic Ether. *By* Alfred R. Catton, *M.A.*

On Mitscherlich's Law of Isomorphism, and on the so-called cases of Dimorphism. *By* Alfred R. Catton, *M.A.*

On the Coal-Tar Bases. *By* J. Dewar.

Last year the author communicated a paper to the Royal Society of Edinburgh on the Oxidation of Phenol by Permanganate of Potash. He found that the principal product of the reaction was oxalic acid, mixed with a small quantity of an acid giving a violet reaction with ($Fe_2\,Cl_6$) ferric chloride. He found it impossible to procure this acid in quantity, but what he had succeeded in making had the melting-point and reactions of salicylic acid. He has attacked the coal-bases by the same reagent.

Picoline can be easily attacked by permanganate of potash at 100° C. The oxidation products are ammonia, nitric and carbonic acid, a small quantity of volatile acids, oxalic acid, and a beautiful crystalline bibasic acid, which the author calls Dicarbopyridenic. The empirical formula of the acid is pyridine plus 2 carbonic anhydrides or typically $(C_5H_3N)^{CO_2H}_{CO_2H}$. It is a seven-carbon acid obtained by the destructive oxidation of a six-carbon compound. The formation of this acid is a true synthesis by oxidation, comparable to the elegant synthesis

of phthalic acid from benzol by M. L. Carius. The oxidation of an organic substance may therefore give rise to higher compounds during its passages to

$$\underset{\text{Ammonia.}}{NH_3,} \quad \underset{\text{Carbonic acid.}}{CO_2,} \quad \text{and} \quad \underset{\text{Water.}}{H_2O.}$$

The author will examine the isometric lutidine; one or other should give the acid with great ease. He believes these bases to be produced by the simultaneous action of hydrocyanic acid or ammonia on acetylene at high temperatures, and intends investigating their action.

On Kekulé's Model to illustrate Graphic Formulæ. By J. Dewar.

The author exhibited to the Section a model devised by Professor Kekulé to illustrate the structure of organic compounds. He explained the peculiarity of the model consisted in carbon, with its four atomicities, being represented by a small sphere, with four equal wire arms joining the centre of the sphere with the angles of an imaginary equilateral tetrahedron; the biatomic and triatomic elements by two and three arms in a plane passing through the centres of small spheres; the lengths of these arms being made so as to join two and three of the extremities of the carbon arms. In order to exhibit the facility with which the model could be used in lecture illustration, he demonstrated to the Section the structure of a number of organic compounds, both fatty and aromatic. He also showed the ease with which it could be applied to explain the differences in the isomeric cyanides and similar cases. In all cases the model gave elegant symmetrical figures, clearly showing the relations of the different groups in the compounds. He afterwards referred to certain peculiarities of the model of some importance. The arms attached to the individual atoms might be looked upon as unit forces, the length of the arms being considered as bearing some relation to their respective magnitudes. Now in this model, although the specific atom has its unit values equal, they are not the same as the unit values in other atoms. In other words, although oxygen is biatomic and can saturate two units of the carbon atom, it is represented as a resultant and not as a sum. This prevents the student from confounding the number of units of attacking power, and any comparison between the values of the individual units in different atoms. The author concluded by advocating the judicious use of such a model in the tuition of organic chemistry, as a great aid in conveying clear and definite notions on the acknowledged intricate questions of atomicity and chemical structure.

On the Vapour-tension of Formiate of Ethyl and of Acetate of Methyl. By W. Dittmar.

The author reports on experiments instituted for determining, by direct comparisons, the difference of the vapour-tensions, at a series of temperatures, of the two metameric ethers named. The determinations were made by the statical method, and the apparatus constructed so that the two vapours (enclosed in vertical glass tubes) pressed against each other through one continuous mass of mercury, and that consequently the difference in tension was obtained directly by the measurement of the difference of level of two menisci, which was effected by means of a cathetometer.

The author, after detailing the methods used for preparing and testing the substances operated upon, gives the result of thirty experiments in a table, of which the following is an extract:—

$$\left.\begin{array}{l}\text{Tension of formiate} = f \\ \text{Tension of acetate} \;\; = a\end{array}\right\} \text{at } t^\circ \text{ C. in millims. of mercury of } 15^\circ \text{ C.}$$

$t = +18$	....29·5	48·6	55·15	69·0	78·95
$f-a = +15·35$	....21·6	36·1	41·5	52·75	59·2

The results lead to the conclusion that at temperatures between 18° C. and 80° C. the vapour-tension of formiate of ethyl is greater than that of acetate of methyl, and that the difference increases with the temperature.

On the Combustion of Gases under Pressure.
By Professor EDWARD FRANKLAND, *Ph.D., F.R.S.*

The author commenced by stating that the idea of the paper arose from observing the reduction in luminosity when a candle or gas-flame is burnt in rarefied air, and the law deduced therefrom was that the diminution of illuminating power was exactly in proportion to the diminution of atmospheric pressure. Some years ago, while the author was on the summit of Mont Blanc at night, he was struck with the want of illumination in the candles burnt in the tent in which they stopped for the night. He had observed similar results in other elevated regions. The diminution of the illuminating power was due to the reduction of atmospheric pressure. The commonly received opinion was that there must be incandescent solid substances in flames in order to produce a white light; but if they took an ordinary gas-flame, and placed a piece of paper with writing on it behind the flame, looking steadily through it, they would be able to read the writing as well, or nearly as well, as if the flame were not there at all, thus showing that flame was transparent. In following out this subject, he had been brought into contact with a number of flames which emitted a considerable amount of light, but which did not contain any solid matter whatever. One was metallic arsenic burnt in oxygen gas. It emitted an intense and brillant white light. Bisulphide of carbon also emitted a very intense light when burnt in oxygen; indeed so intense that it had been employed to take instantaneous photographs. This was produced without the possibility of a solid or liquid matter existing in the flame while the light was being evolved. If oxygen and hydrogen were enclosed in a soap-bubble or other light envelope, and exploded, there was scarcely any light produced; but if they were enclosed in a strong vessel and exploded by means of an electric spark, an intense light was produced, the pressure or density at the moment of explosion being ten times as great as that in the previous case. Ignited gas emitted light in proportion to its density. The luminosity in ordinary flames, such as those of gas and candles, the author considered to be due to the presence of dense hydrocarbon vapours. One of the most interesting experiments shown was that of sending an electric spark first through air under ordinary pressure, and then through air under double pressure. The result was that the light of the spark due to ignition of the air was very much increased. The spark was sent also through many other gaseous and vaporized substances, showing most conclusively that the greater the vapour-density of the bodies the greater was their luminosity when submitted to ignition by the electric spark.

On Refraction-Equivalents and Chemical Theories.
By J. H. GLADSTONE, *Ph.D., F.R.S.*

The refraction-equivalent of a substance has already been defined before the British Association as the refractive index minus unity divided by the specific gravity; and the largest generalization that has been made in reference to the matter is that the refraction-equivalent of a compound is the sum of the refraction-equivalents of its constituents. If this were universally true, it would be easy to determine the equivalents of all the elements; but it is certain that some of these have more than one manner of affecting the rays of transmitted light.

While investigating this subject, the author perceived that the numbers arrived at for different elements or compounds had a chemical as well as physical interest, and a bearing on certain chemical theories.

Thus Roscoe has given various reasons for considering vanadium as an element analogous to phosphorus. If so, it might be expected to have a very high refraction-equivalent. The oxychloride of vanadium was examined and gave the number 57·8, which, allowing 33 for the chlorine and oxygen, leaves 24·8 as the equivalent of vanadium, showing an amount of refraction totally different from that of the metals, and comparable only with sulphur and phosphorus. It is also, like these substances, extremely dispersive.

Hydrogen, in the mineral acids, such as sulphuric and hydrochloric, has the equivalent 3·7; but in organic acids, such as acetic or citric, it gives only 1·3, its

usual equivalent in organic bodies. This seems to indicate a difference of constitution in these two great classes of acids.

The well-known group of metals, iron, nickel, cobalt, and manganese give, in their protosalts, respectively 5·7, 5·8, 5·4, and 5·9, the same number within limits of probable error; but iron in its ferric salts or in the case of the compound cyanides gives about double that number. A similar case of "Diphotism" occurs with manganese in its ordinary salts, and in the condition of permanganate where it was determined at 11·5. Chromium and aluminium belong also to this group, giving analogous numbers.

There is no appreciable difference in the refraction of solutions of tartaric and racemic acids; the first giving 45·25, the second 45·10.

The specific refractive energies of the metals already examined are (with one or two exceptions) in the inverse order of their chemical equivalents. If this should prove to be a law, it may be the means of deciding between the multiple numbers that are assigned as the chemical equivalents of certain elements.

Different Spectra of one Chromium Salt. By R. GERSTL.

Note on Methylacetonamine, Ethylacetonamine, and Amylacetonamine. By FREDERICK GUTHRIE.

Acetonamine is obtained by digesting acetone for many days in a large flask containing dry ammonia, and evaporating off the excess of acetone in a water-bath. The composition of acetonamine is given as $C_9 H_{18} N_2$.

If syrupy acetonamine be mixed with iodide of methyl heat is evolved, and direct union ensues. A crystalline body is formed, soluble in water, and more so in alcohol, which is found after purification to have the formula $C_9 H_{18} N_2 (CH_3 I)_2$, or iodide of methylacetonamine

Iodide of amyl gives rise to a similar body, but the formation of the amyl compound requires the application of heat. The iodide of amylacetonamine, $C_9 H_1 N_2 (C_5 H_{11} I)_2$, crystallizes from alcoholic solution in pearly scales. Chloride of amylacetonamine may be formed in a similar manner.

The iodide of ethylacetonamine is more difficult to obtain, but its composition and properties are similar to the methyl and amyl derivatives.

Note on the Vesicular Structure of Copper. By Dr. MATTHIESSEN, *F.R.S.*, *and* Dr. W. J. RUSSELL, *F.C.S.*

At the Meeting of the British Association at Manchester, the authors described some experiments on the vesicular structure of copper, and showed that it might be produced by the action of such reducing-agents as hydrogen, carbonic oxide, coal-gas, and charcoal on melted copper containing suboxide. The numerous experiments made abundantly proved that, with pure copper fused entirely out of contact with the air, no vesicular structure is produced; but, on the other hand, if fused copper be exposed, even for a moment, to the air, and then charcoal be thrown upon it, or it be exposed to the action of a reducing-gas as it cools, then vegetation and spitting of the metal is always produced, and it is found to be more or less vesicular.

This explanation of the phenomenon is apparently so complete and satisfactory, that the authors would not have again returned to the subject if M. Caron had not obtained results which lead him to conclusions somewhat different from theirs. He fused considerable quantities of copper, some 200 grms., in a boat within a large porcelain tube, and was able to observe the changes which the copper underwent. On passing a current of hydrogen or carbonic oxide through the tube, the copper being melted, he believes that an absorption of these gases takes place, and since they are entirely given out again on the metal cooling, this elimination of the gas causes a spitting and a vesicular structure in the metal.

M. Caron states further, that when the vessel which contains the melted copper is made of graphite, unglazed porcelain, or lime, there is no vesicular structure produced; in fact, as far as his experiments go, the spitting only occurs when the fusion takes place in a glazed porcelain vessel. The authors have repeated M.

Caron's experiments, and can fully confirm his results so far that, when copper is fused in a rapid stream of hydrogen and in a graphite boat, the copper is not vesicular, but when fused in a glazed porcelain boat, there are cavities in the copper. Supposing, as M. Caron does, that hydrogen is soluble in melted copper, it is difficult to explain how this solubility is diminished to such an extent as not to be appreciable when the not glazed vessel is used. Further, there is no doubt (for it is an experiment that has been repeated many times) if copper be fused with a layer of charcoal over it, and a rapid current of hydrogen be bubbled through it, no trace of the vesicular structure is visible. From the experiments they have already made on the subject, the authors feel no doubt that the cavities in the copper are owing to a decomposition of the glaze; for they find that the glaze is always much acted on by the copper, that the cavities are always in the lower part of the ingot where it is in contact with the porcelain, and that the copper, instead of being vesicular throughout its mass, is very dense and tough, the cavities full of crystals. What the decomposition is which takes place, and how the gas comes to be eliminated in this way, it will take further experiments to explain, but the authors have no hesitation in saying that they do not believe hydrogen is dissolved at all by melted copper.

On Paraffin, and its Products of Oxidation.
By Dr. E. Meusel *and* C. Haughton Gill, *F.C.S.*

Paraffin, on being submitted to the prolonged action of dilute nitric acid, or of potassic dichromate somewhat diluted, and sulphuric acid, becomes gradually oxidized, and yields a number of fatty acids, the highest term of which is cerotic acid, $C^{27} H^{54} O^{2}$, and the lowest acetic acid. The oxidation of nitric acid also gives rise to the formation of succinic and anchoic acids, owing to a secondary action of the oxidizing agent on the cerotic acid, formed by the first oxidation of the paraffin.

The fatty acids which are formed by oxidation of the hydrocarbons are separated from unaltered paraffin by converting them into soda soaps, and dissolving these out from the paraffin by dilute alcohol. They are then separated by Heintz's method of partial precipitation, the cerotic acid being finally obtained in a pure state by repeated crystallization from a mixture of alcohol and ether.

The paraffin used melted at 56° C., but could be separated into portions, melting higher and lower, and was therefore a mixture of various hydrocarbons. It would not combine directly with bromine, though its hydrogen was easily replaced by that element. It formed no compound with sulphuric acid, either fuming or monohydrated. From all which experiments, the authors concluded that paraffin is a mixture of various hydrocarbons, of the series $C^{n}H^{2n+2}$, and that in the sample employed there was one term of the series having a carbon condensation not lower than equal to C^{27}.

On a Physical Property of two Coloured Compounds.
By Dr. Edward Meusel.

One of these compounds, consisting of mercuric iodide with argentic iodide, is obtained by adding argentic nitrate to a solution of mercuric iodide in potassic iodide. A yellow precipitate is formed, which, well washed and dried at a low temperature, turns instantaneously red when exposed to a temperature above 50° C.

The other compound, consisting of mercuric iodide with cuprous iodide, is prepared in the same manner, with the difference of cupric sulphate being added instead of argentic nitrate. At first a greenish-white precipitate is obtained, which, when shaken and heated, darkens, gives off iodine and turns red. The latter precipitate is as sensitive as the silver compound, and rise of temperature causes it to turn black.

Both colours, allowed to cool, return to their original tint, an experiment which may be very often repeated with the same substance.

Besides these two new iodine compounds, the author has found corresponding ones containing lead, gold, &c.

On the Manufacture of Sulphur from Alkali Waste in Great Britain. *By* Dr. LUDWIG MOND.

The author called attention to a new industry—the recovery of sulphur from alkali waste, which had made very rapid progress during the past few years. The importance of the subject had been very ably pointed out in 1861 by Mr. Gossage, in a paper "On a History of Soda Manufacture." Mr. Gossage stated that two-fifths of the total cost for raw materials used for the production of a ton of soda-ash was incurred for pyrites from which to procure a supply of sulphur; and it was well known that nine-tenths of this sulphur was retained in the material called alkali waste, which was thrown away by the manufacturer. A problem was thus presented for solution, which, if it could be effected, would cause a large reduction in the cost of soda. The author stated that the problem had been very near a satisfactory solution, and called attention to a process with which his name was connected. He took out a patent in 1863 for the process, and its merits had been very fully recognized in this country. The process was carried out in the following way:—The first product of Leblanc's famous process for the manufacture of soda, called rough soda or black ash, was now almost universally lixiviated with water in an apparatus which was first used for this purpose in Great Britain, and was composed of a number of iron tanks connected in a very simple manner by pipes and taps, &c., so as to allow the water to enter a tank filled with black ash already nearly spent, and thence to flow through others filled with black ash richer and richer in alkali, until it met fresh black ash in the last tank, thus becoming an almost concentrated solution of alkali before leaving the apparatus. The alkali waste, or insoluble residue of the black ash, remained thus in these tanks deprived of alkali, and as it had been immersed in the liquor throughout the whole time of lixiviation, it was consequently obtained in a very porous condition. The tanks were always provided with a false bottom. The whole process of oxidation and lixiviation of the waste, though it was repeated three times, was finished in from sixty to seventy-two hours. When the waste left the tanks, all the recoverable sulphur had been taken out of it, and could no more give rise to the dreadful exhalations of sulphuretted hydrogen, or to the formation of those well-known yellow drainage liquors which had hitherto caused the waste to be so great a nuisance, the one poisoning the air and the other the water in the neighbourhood of the vast heaps of waste surrounding many works. Almost all the sulphur left in the waste existed in the form of sulphite and sulphate of calcium, which were both innocuous; and together with the carbonate and hydrated oxide of calcium, as well as with a little soda, alumina, and soluble silica, which were all to be found in the waste, made this waste a very valuable manure for many soils and crops. By other processes which the author explained, he obtained sulphur of a dark colour, the waste from which was turned to advantage and made comparatively harmless. By the author's processes fully one-half of the sulphur contained in the waste was recovered. The cost was small. A plant for the recovery of 10 tons of sulphur per week would be about £800; and the sulphur could be made at £1 per ton. The recovered sulphur being very pure, was not used to replace pyrites in the manufacture of soda; but for purposes where Sicilian sulphur or brimstone had hitherto been employed, this Sicilian sulphur having a much higher value than the sulphur in pyrites, and averaging upwards of £6 per ton. And so large were the quantities of brimstone used, that the British alkali trade, in spite of its enormous extent, could only produce a small portion of the sulphur yearly exported from Sicily, which country had hitherto had the monopoly of the supply of this article.

On Chloride of Methylene obtained from Chloroform by means of Nascent Hydrogen. *By* W. H. PERKIN, *F.R.S.*

From the history of monocarbon derivative, as it stands at present, it would appear that there exist several bodies isomeric with each other; thus we have the description of two bromides of methyl, the one liquid and the other gaseous; two chlorides of methylene, the one boiling at 30°·5 C., and the other at 40° C., &c. Yet it is considered by some chemists that this isomerism is improbable, and that these substances, if reexamined, would be found to be identical.

This question being one of considerable importance, and bearing upon the nature of the derivative of not only carbon but probably of all other polyatomic elements, the author commenced a fresh examination of some of these monocarbon derivatives, hoping that an experimental comparison of their properties might in some degree help to a solution of this problem.

In this communication only a short account was given of some experiments upon the chloride of methylene, obtained from chloroform by means of nascent hydrogen, and which had been previously used by Dr. Richardson as an anæsthetic. The reagents employed were powdered zinc and ammonia, which react with violence upon chloroform.

The chloride of methylene obtained by this method boiled at about 40°·5 to 41° C., and would therefore appear to correspond to that obtained by Butlerow from the iodide of methylene. Its formula was determined by combustion and Gay-Lussac vapour-densities, and these gave results showing it to have the composition $CH_2 Cl_2$.

The author proposes to examine the products of decomposition, and also to prepare a quantity of Regnault's chloride of methylene from chloride of methyl and chlorine, that he may compare these two substances.

Note on the Preparation of some Anhydrous Sodium Derivatives of the Salicylic Series. *By* W. H. Perkin, *F.R.S.*

In the preparation of salts or other metallic derivatives of organic bodies by means of oxides, there is always an equivalent of water produced, unless the substance acted upon be an anhydride; therefore if the resulting compound has any tendency to form hydrated products, such are nearly sure to be produced, and it often happens that it is difficult or impossible to remove this combined water. Having to prepare a quantity of the hydride-of-sodium salicyl in an anhydrous state, it appeared desirable, if possible, to obtain it anhydrous at once, and thus avoid the blackening and loss which it is subject to unless dried very rapidly. This object was effected by employing sodium-alcohol instead of a solution of hydrate of sodium, alcohol only being liberated when this substance enters into double decomposition with the hydride of salicyl. The hydride-of-sodium salicyl obtained in this manner is perfectly anhydrous, and of a beautiful pale primrose-yellow colour.

By treating salicylic acid with sodium-alcohol, a new sodium derivative, crystallizing in needles, was obtained. This product contains two equivalents of sodium, and therefore corresponds to the dimetallic derivatives of Piria. It has the following composition, $C_7 H_4 Na_2 O_3$.

Salicine also yields a sodium derivative, when treated with sodium-alcohol, having the formula $C_{13} H_{17} NaO_7$. This body is but slightly soluble in alcohol, and not very crystalline. It is deliquescent.

On Sulphocyanide of Ammonium. *By* Dr. T. L. Phipson, *F.C.S.*

In this paper the author alludes, first, to the estimation of sulphocyanogen in a mixture of sulphate, chloride, and sulphocyanide of ammonium. He effects this by precipitating the slightly acid solution by a mixture of equal equivalents of sulphate of protoxide of iron and sulphate of copper. The precipitate dried at 100° C. contains Cu^2, $C^2 NS^2$.

Attention is next called to some properties of sulphocyanide of ammonium. The author finds that this salt produces a great degree of cold in dissolving rapidly in water. Half a litre of water at 96° C., poured on 500 grms. of the impure salt extracted from gas-liquor, caused the thermometer to sink to 2°. In a more exact experiment, 35 grms. of pure sulphocyanide of ammonium, stirred rapidly with 35 cub. centims of water at +26° C., the thermometer descended in a few seconds to −10°; the moisture of the atmosphere condensed itself in plates of thin ice on the exterior of the glass vessel.

It is next shown that the alcoholic solution of this salt presents the peculiar phenomena of *supersaturation* in the highest degree.

The action of iodine, bromine, and chlorine upon sulphocyanide of ammonium is very remarkable. These bodies are absorbed in large quantities by the concentrated aqueous solution of the salt, and when it is heated the compound called sulphocyanogen is precipitated. This was submitted to analysis, with the following results:—

	Phipson.	Calculated.
Carbon...................	20·00	19·83
Hydrogen	0·78	0·82
Nitrogen	23·20	23·14
Sulphur	53·00	52·48
Oxygen	3·02	3·73
		100·00

which agrees with the formula $C^5 H^2 N^4 S^5 O$, formerly admitted by Herr Voelkel, and not with that of Laurent and Gerhardt, which demands 24 of N, and nearly 55 of S ($C^6 N^3 HS^6$); these authors, however, estimated only the CH and S; their nitrogen was obtained by difference.

In dilute solutions the action of chlorine oxidizes the sulphur of the sulphocyanide, and no precipitate is formed.

The crystals of sulphocyanide of ammonium appear to be derived from the right rectangular prism; they are often very fine, and sometimes grouped together in wide crystalline plates several inches broad.

General Outline of an original System of Chemical Philosophy, comprising the Determination of the Volume-equivalents, as also a new Theory of the Specific Volumes of Liquid and solid Substances. By OTTO RICHTER, *Ph.D.*

In this paper the author proceeds upon the hypothesis that the chemical elements consist not of individual atoms, but of entire groups of such atoms, in other words, of molecules. The various kinds of elementary molecules agree in being, each and all, built up of precisely the same number of atoms, which are symmetrically disposed with reference to the three axes of space, according to the same fundamental plan of arrangement. The constituent atoms of these elementary molecules are each and all endowed with the same three fundamental properties of gravity, original elasticity, and electrical energy, and these properties vary in range and intensity with each species. In harmony with the common practice, the chemical elements are divided into the two principal classes of the metals and the non-metals, represented respectively by the general formulæ Mt_2 and Nt_2. The constituent atoms of the molecules, from the simplest to the most complex, are further supposed to be in a perpetual state of vibration, in which they perform a series of periodical contractions and expansions, and thus, in their final effect, establish between contiguous molecules a permanent tendency to repulsion, the result of which is the formation of a certain space round the centre of each molecule, which constitutes its specific volume, and is always directly proportional to the number of atoms set in motion. The volume-equivalents represent the maximum specific volumes which the elementary molecules are capable of realizing; and the peculiar force, under the influence of which the vibratory movements of the atoms may *ad libitum* be arrested or restored, is called "*the paralytic force.*" The order in which this force performs its operations in the complex molecules materially depends upon the particular position which the various constituents occupy in the system relatively to each other. This law of Rankorder is indicated in the table of chemical equivalents, in so far as any chemical element which stands to the left or to the right of any other is supposed to occupy in a certain sense a similar position in comparison with any other with which it happens to be associated as a constituent member of the same type. The science of chemistry is divided into two parts, "Pondo-chemistry and Impondo-chemistry." The former treats exclusively of the molecular arrangement of the constituents, the latter exclusively of their specific volumes. Pondo-chemistry is divided into the two principal sec-

tions of meta-chemistry, which is subject to the dominion of the principle of polarity, and includes eleven distinct types, and of para-chemistry, which is subject to the principle of parality, and includes three distinct types or forms of molecular grouping. After giving a general description of these various types, the author discusses the law of volume-harmony, according to which the volumes of the constituent members of a given volume-harmonious molecule are always reducible to some simple ratio contained in the volume-harmonious scale: $1:m\times1$; $1:m\times2$; $2:m\times3$; $3:m\times4$; $4:m\times5$; $5:m\times6$; $6:m\times7$, where m represents some integral number. The volume-harmonious molecules are divided into two classes. The first class comprises all those compounds where the water of crystallization is excluded, and the second class all those compounds where the water of crystallization is present. As regards the latter class, it is a characteristic peculiarity that in the process of reduction the saline molecule, with every fresh addition of one molecule of water of crystallization, experiences a loss in volume amounting always to a constant quantity. This quantity remains unaltered so long as this loss in volume is caused by the successive paralysation of its envelope-molecules; but when this process of reduction extends to the molecules of the nucleus, the constant quantity in some cases continues the same, but in general it merges into another constant quantity. Further details, in particular as regards the various conditions and rules intended to guide the student in the volume-analysis of the molecules belonging to the parachemical system, are contained in the original paper.

Analysis of the Roman Mortar of Burgh Castle, Suffolk. *By* John Spiller, *F.C.S.*

The samples of ancient Roman mortar which form the subject of this memoir, were detached for the purpose of analysis in the years 1863 and 1866. They all had the reddish colour (due to the admixture of pounded brick) which is considered to be characteristic of a Roman origin. The details of construction, dimensions, and other particulars relating to Burgh Castle, the *Garianonum* of the Romans, were briefly described, and a water-colour sketch of the *castrum* exhibited. The walls, which are of rubble masonry and about six feet in thickness, are faced with flints and triple layers of red tiles, set with great regularity.

Adopting Mr. C. Roach Smith's opinion respecting the antiquity of the *castrum*, the chemical problem resolved itself into a study of the following leading points in reference to the hardening of the mortar, and changes occurring during a period of about fifteen centuries, viz.:—

1st. To what extent the hydrate of lime becomes recarbonated by exposure to air?

2nd. What is the physical condition of the carbonate so produced? and

3rd. Whether in this long interval the silica and lime can directly unite with each other?

The conclusion to which the author was led by the chemical examination of the ancient mortars from Burgh, Pevensey, and other Roman *castra*, is that the lime and carbonic acid are invariably united in monatomic proportions as in the original limestone rock, and that there is no evidence of the hydrate of lime having at any time exerted a power of corroding the surfaces of sand, flint, pebbles, or even of burnt clay, with which it must have been for lengthened periods in contact. Further, that the water originally combined with the lime has been entirely eliminated during this process of recarbonation, and, this stage passed, the amorphous carbonate of lime seems to have become gradually transformed by the joint agency of water and carbonic acid into more or less perfectly crystallized deposits or concretions, by virtue of which its binding properties must have been very considerably augmented.

The analytical method was described, and the following results were reported as expressing the composition of the Roman mortar, and also of the red bricks or tiles, which are remarkable for their fine texture and excellent manufacture.

Analysis of the Roman Mortar from S.E. Tower, Burgh.

	I.
Sand	54·50
Soluble silica	0·40
Red brick with some unburnt clay	18·00
Carbonate of lime	25·75*
Sulphate of lime	0·15
Carbonate of magnesia	0·08
Chloride of sodium	0·05
Magnetic oxide of iron, Wood charcoal	traces
Water, chiefly hygroscopic	0·92
Total	99·85

Other Samples of Burgh Mortar.

	II.	III.	IV.
Sand and brick, with a little unburnt clay	72·3	71·4	67·0
Carbonate of lime, &c. (by difference)	27·7	28·6	33·0

Samples II. and III. were taken from the south wall; specimen IV. from the north wall.

Red Brick, or Tile, from S.E. Tower, Burgh.

Silica	72·7
Alumina	14·0
Peroxide of iron	10·0
Lime	2·1
Magnesia, Oxide of manganese	traces
Alkalies and loss	1·2
	100·0

On the Absorption of Gases by Charcoal. By Dr. R. Angus Smith, *F.R.S.*

The author said that he had somewhat further extended his inquiries into the laws of absorption of gases, as shown by charcoal. He had some years ago said that he believed the actions were on the border between chemistry and physics, or that physical phenomena were an extension of the chemical. Last year, in a short note, he stated that the gases which he tried were absorbed in whole volumes, or volumes which were multiples of hydrogen. He had now tried other gases, with the following results:—Hydrogen, 1; oxygen, 7·99; carbonic oxide, 6·03; carbonic acid, 22·05; marsh-gas, 10·01; nitrous oxide, 12·90; sulphurous acid, 36·95; common air, 40·063. Nitrogen was found to be 4·27; probably this is a little too low, as there is always some nitrogen left in the heated charcoal. These numbers are got by dividing the number of volumes absorbed by each gas by the volumes of hydrogen absorbed. They are an average of many experiments. The numbers in some cases differ considerably; it is supposed that the reason lies in the constitution of the charcoal, but it may be partly owing to the mode of working.

He considered that the ultimate particles of gas rested as strata or layers in the charcoal; the outer particles were therefore less forcibly held than the more distant. The latter were also most difficult to remove. If this physical action had an analogy with chemical action, it would probably throw light upon it, and it seemed to point to compounds containing parts held together more or less loosely than other parts. The gas and charcoal form such a compound, which in a sense is not purely chemical

Two of the numbers seem to be very remarkable; namely, those of oxygen and carbonic acid, as the volumes are exactly those of the weights of oxygen in water and of an atom of carbonic acid. Eight volumes of oxygen are 128 times heavier than

* Found, lime 14·5, carbonic acid 11·25 per cent.

one volume of hydrogen; the gases, therefore, do not seem to be taken up according to their atomic weights. By attention to this, he hoped that some light would be thrown on the physical atomic constitution of bodies.

In a practical point of view, he hoped to gain by the inquiry some knowledge of the phenomena of spontaneous combustion to which several substances are subjected.

Experiments on the absorption of mixed gases had been made, but were left for future description, and also those on the extrusion of one gas by another.

Experiments on salts were not sufficiently telling, and a better mode of making them had to be found; but it was clear to him that the charcoal took up most readily those oxides the metals of which were less inclined to oxidize. The combinations being weaker, the bases were removed from the acid, a struggle against chemical action existing. In other words, an action with little chemical character opposed itself to the purely chemical, and by aid of mass gained something, a phenomenon which is frequent whenever chemical action is weak, and one which interferes much with exactness in analysis.

On the Action of Nuclei in inducing Crystallization. *By* Charles Tomlinson, *F.R.S.*

It had been noticed during the last three-quarters of a century that solids acted as nuclei in liberating gases from their solutions (soda-water, champagne, &c.), or in inducing crystallization in saline solutions, only under certain conditions. If they had been previously exposed to the air, they were "active;" if kept in water, and dried out of contact with the air, or if passed through flame, or boiled up with the saline solution, they become "inactive" as nuclei. Hence it was supposed that there was some mysterious property in the air which converted "inactive" into "active" nuclei.

The author explains the action of nuclei with reference to differences in the force of adhesion acting on chemically clean or chemically unclean surfaces. If chemically clean, the solution, whether of gas in water or of salt in water, will adhere to such surfaces as a whole, and there will be no separation either of gas or of salt. But if by exposure to the air, or by handling, &c., a nucleus, such as a glass rod, be made chemically unclean, the force of adhesion will be different. The gas or the salt of the solution will adhere to the unclean surface; the water of the solution will not do so, or, at any rate, but feebly; hence there will be a separation of the gas or of the salt, and the nucleus will be "active" when, in fact, it is simply unclean.

When supersaturated solutions are kept in clean tubes and protected from the air by having the mouths plugged with cotton-wool, many of them may be kept during a long period without any separation of the salt. They may even be reduced to low temperatures, approaching zero (Fahr.), without change of state. During a rising barometer air enters the tubes, the cotton-wool filtering it from the motes and dust which act as nuclei, the air itself not being a nucleus. During a falling barometer, on the contrary, air escapes from the tubes, and drags away with it some of the aqueous molecules of the solution. The effect of this action, then repeated, is to depress the liquid-surface and leave a ring of salt just above it. This salt being chemically clean does not act as a nucleus to the rest of the solution; and the latter being supersaturated does not dissolve it. We may even lower clean crystals of the salt (the magnesic sulphate is well adapted to the experiment) into a cold highly supersaturated solution, without any action on their part as nuclei in inducing crystallization. The author described two experiments of this kind with magnesic sulphate; and in answer to an objection that in nursing a crystal of alum, for example, we must be dealing with chemically clean surfaces, he showed that in such a case none of the conditions of chemical purity were observed; the evaporating-dish and the solution exposed to the air were chemically unclean, as was also the hair by which the crystal was suspended, while the crystal itself was frequently handled, and abnormal growths chipped off with the thumbnail; the result of all this being the production of an opaque octahedron from the deposit of a multitude of minute crystals upon chemically unclean facets.

The author's definition of a chemically clean surface is as follows:—

A chemically clean surface is one that has on it no film or coating of any substance whatsoever foreign to its own composition. As oxidation by the air, organic matter, and floating motes are the most usual forms of films, it may be said loosely, that any substance that has been exposed for some time to the air is chemically unclean; but speaking strictly, a film of any foreign matter will render a surface unclean for some conditions or other in the experiments in hand.

A chemically unclean surface, then, may be generally defined as anything that is exposed to the products of respiration or of combustion, or to the touch, or to the motes and dust of the air, and so becomes covered with an invisible film more or less organic. So also any vessel or surface wiped with a cloth that has been exposed to the air is chemically unclean.

Note on Sea-water. *By* Professor J. A. Wanklyn.

It has been shown during the past year that deep spring-water contains no organic nitrogenous matter, and that the water of rivers and lakes contains nitrogenous organic matter in the proportion of about one part of nitrogenous organic matter to a million of water. The water of the sea contains about one hundred times as much solid matter as the water of rivers and lakes. The author asked himself the question whether the nitrogenous organic matter increases in anything like that proportion. An examination of sea-water collected off the coast of Devonshire (at Teignmouth) has been made accordingly, with the object of answering this query. The result is that there is about double or treble as much nitrogenous organic matter in sea-water; so that the total solids increase far more rapidly than the organic matter.

Researches on the Ethers. *By* Professor J. A. Wanklyn.

Five cubic centimetres of good acetate of ethyl and 0·3 grm. of sodium were sealed up in a small glass tube, and then heated in the water-bath to 100° C. until all the sodium had disappeared. The tube was then opened under water, and the gas which escaped measured 25 cubic centims. at the ordinary temperature of the air. Reduced to 0° C. and 760 millims. pressure (dry), the volume of the escaped gas is about 23 cubic centims. If the volume of hydrogen which is equivalent to 0·3 grm. of sodium be calculated, it will be found to be about 140 cubic centims. Therefore this experiment establishes the fact that there is no evolution of hydrogen as a main product of the action of sodium on acetic ether. Moreover the 23 cubic centims. of gas which escaped must be regarded as due to traces of alcohol in the acetic ether, and not as arising from minor secondary reactions on the acetic ether. About 2 per cent. of alcohol present in the acetic ether (and such a quantity was very probably there) is sufficient to account for 23 cubic centims. of hydrogen. Another sample of acetate of ethyl, which had been very carefully prepared, evolved no gas at all when acted on by potassium or sodium.

Acetate of Amyl and Sodium.—The acetate of amyl was very carefully deprived of all traces of amylic alcohol by being treated with glacial acetic acid and hydrochloric-acid gas. After this treatment it gave correct numbers on titration. 0·6 grm. of sodium and 11 cubic centims. of acetate of amyl were sealed up in a small tube and heated to 100° C., until all the sodium had dissolved; the tube was then opened under water. Not a trace of gas was evolved. (Calculating the quantity of hydrogen equivalent to the 0·6 grm. of sodium, it will be found to exceed 250 cubic centims.)

Butyrate of Ethyl and Sodium.—The ether boiled at 118°·5 C., and was consequently the normal (not the iso-) butyrate. On being titrated it gave very correct numbers. 37 grms. of this butyric ether, 7·5 grms. of sodium, and 40 cubic centims. of dry common ether,

$$\left.\begin{matrix} C_2H_5 \\ C_2H_5 \end{matrix}\right\} O,$$

were sealed up and heated very gently in the water-bath, and shaken up well

during the progress of the reaction. The sodium dissolved without any evolution of gas. The experiment was repeated with the same result.

Valerianate of Ethyl and Sodium.—There is not the slightest evolution of gas when these materials act on one another.

Benzoate of Ethyl and Sodium.—Pure benzoic ether and sodium and common ether were sealed up and heated in the water-bath. There was action, but no evolution of gas.

From these experiments it is abundantly evident that free hydrogen forms no part of the product of the action of sodium on the ethers of the fatty and aromatic acids.

All the modes of explaining the action of sodium on acetic ether adopted by Geuther, Frankland, and Duppa must therefore, in the author's opinion, be abandoned. The memoirs of these chemists agree in representing the action of sodium as consisting in the evolution of an equivalent of hydrogen for every equivalent of sodium consumed. Thus Geuther writes the following equation to express the action of sodium on acetic ether:—

$$\underset{\text{Acetic ether.}}{2C_4H_8O_2} + Na_2 = \underset{\text{Ethylate of sodium.}}{NaC_2H_5O} + \underset{\text{New body.}}{C_6H_9O_3Na} + H_2.$$

Frankland and Duppa write:—

$$4C_4H_8O_2 + Na_2 = 2C_2H_6O + 2C_6H_9O_3Na + H_2.$$

Also:—

$$2C_4H_8O_2 + Na_2 = C_2H_6O + C_6H_8O_3Na_2 + H_2.$$

Also:—

$$2C_4H_8O_2 + Na_2 = 2C_4H_7NaO_2 + H_2.$$

Also:—

$$C_4H_8O_2 + Na_2 = C_4H_6Na_2O_2 + H_2.$$

All these equations affirm the evolution of as many equivalents of hydrogen as there are equivalents of sodium consumed. From this view the author dissented.

In order to account for the different results given by the eminent chemists just referred to, it will perhaps be enough to make the remark that they appear to have omitted to measure the equivalent of hydrogen, which nevertheless appears in their equations*. The author on former occasions represented the action of sodium on valerianic ether as consisting in the replacement of the acid-forming radical by sodium and the generation of free valeryl or sodium-valeryl, according to circumstances. A mode of representation of this kind will have to be adopted by chemists for the explanation of the reaction between sodium and acetic ether. Geuther, Frankland, and Duppa agree (here the agreement rests on an experimental basis) in representing a body having the formula $C_6H_9O_3Na$ as a product of the action of sodium on acetic ether. Geuther obtained and analyzed it, and also the hydrogen, ethyl, and methyl derivatives of it. He also prepared some derivatives containing various heavy metals; and he investigated quantitatively a very interesting decomposition in which water plays a part, and in which acetone, alcohol, and carbonic acid are produced. Frankland and Duppa have prepared the ethyl derivative. Altogether it is well made out that $C_6H_9O_3Na$ is produced, and that it is the main, if not the only, new compound *directly* resulting from the action of sodium on acetic ether. Very complicated names have been given to it, viz. "æthylen-dimethylencarbonsaure-natron" by Geuther, and "ethylic sodacetone-carbonate" by Frankland and Duppa. On making an inspection of the formula it will be seen that it is equal to three equivalents of acetyl and one of sodium,

$$C_6H_9O_3Na = \left.\begin{matrix}(C_2H_3O)_3\\ Na\end{matrix}\right\};$$

* More than twenty-four years ago Löwig and Weidmann investigated the action of potassium on acetic ether, and arrived at the result that ethylate of potash and a potash-salt of a new organic acid is the product, and that no gas is given off. (Ann. der Chem. und Pharm. vol. xxxvi. p. 297.) In 1864 (Journ. Chem. Soc. vol. ii. p. 371) I called attention to these old researches and confirmed the result in a general way. I showed that sodium and acetic ether might be heated in a bath, the temperature of which was 130° C., without any considerable evolution of gas of any kind.

and its production from acetic ether and sodium admits of the following formulation:—

$$\underset{\text{Acetic ether.}}{3\left.\begin{matrix}C_2H_3O\\C_2H_5\end{matrix}\right\}O} + Na_4 = \underset{\text{Ethylate of soda.}}{3\left.\begin{matrix}Na\\C_2H_5\end{matrix}\right\}O} + \underset{\text{Sodium triacetyl.}}{\left.\begin{matrix}Na\\(C_2H_3O)_3\end{matrix}\right\}}.$$

No other equation is capable of rendering a rational account of the production of $C_6H_9O_3Na$ from acetic ether and sodium without necessitating the assumption that there is evolution of hydrogen. This equation affirms that 3 equivalents of ethylate of soda are complementary products to 1 molecule of the new compound; also that 4 equivalents of sodium are required to give 1 equivalent of sodium in the form of new salt. The following experiments accord with these conditions. The author took 2·4 grms. of sodium and dissolved it in excess of acetic ether in presence of dry common ether used as a diluent. When the reaction was over, water was added, by which means of course ethylate of soda would be transformed into caustic soda and alcohol, more or less of the caustic alkali becoming acetate of soda by action on the excess of acetic ether. The difference between the total amount of sodium employed and the sum of the amount of sodium found as caustic soda and as acetate of soda gives the quantity of soda forming the new compound. The following is a tabular statement:—

		grms.
Sodium found caustic	=	1·56
„ as acetate	=	0·24
„ as new compound	=	0·60
Sodium employed......		2·40

Ratio of sodium employed to sodium as new compound:—

2·40 : 0·60,

or 4 : 1.

A similar experiment with potassium and without common ether as a diluent furnished an analogous result:—

		grms.
Potassium found caustic	=	1·59
„ as acetate	=	0·28
„ as new compound	=	0·64
Potassium employed	=	2·51

2·51 : 0·64 :: 3·92 : 1.

Sodium triacetyl, $C_6H_9O_3Na$, admits of being regarded in different lights. For instance, it may be written thus, $(C_2H_3O)_3Na'''$, wherein the sodium is represented as being triatomic, or it may be written thus,

$$\left.\begin{array}{l}C_2H_3O\\C_2H_3\;\;|\;\;|\\\qquad O\;O\\C_2H_3\;\;|\;\;|\\\quad Na\end{array}\right),$$

wherein the three equivalents of acetyl are fused together to consitute a monatomic triacetyl, $C_6H_9O_3$. Hydride of triacetyl, which is very well described by Geuther, is obtained by decomposing sodium triacetyl with glacial acetic acid, and is an oily liquid rather heavier than water; the author has prepared some of it. The decomposition noticed by Geuther which it undergoes in contact with strong acids or alkalies, and in which the elements of water are taken up, is very interesting:—

$$\left.\begin{matrix}C_2H_3O\\C_2H_3O\\C_2H_3O\\H\end{matrix}\right\} + H_2O = \underset{\text{Acetone.}}{\left.\begin{matrix}C_2H_3O\\C_2H_3\end{matrix}\right\}} + \underset{\text{Alcohol.}}{C_2H_6O} + CO_2$$

The formation of alcohol in this reaction is a virtual conversion of acetic acid into alcohol, inasmuch as the triacetyl came from acetic acid.

In the author's opinion the compounds mentioned in Frankland and Duppa's paper as derived directly from acetic ether and sodium admit of representation as sodium triacetyl, and products derived from sodium triacetyl.

On Chemistry as a Branch of Education. By THOMAS WOOD, *Ph.D., F.C.S.*

The author divided chemistry, for the purposes of education, into two distinct and separate studies, first, chemistry as a branch of education teaching facts useful to be known, and secondly, chemistry used as an instrument or means of general, intellectual, and practical training. To teach the former, the head of a school need not invest in either apparatus or a laboratory, as a few well-illustrated lectures are sufficient to enable the pupils to read up the subject. For these the lecturer could bring the necessary apparatus. The latter necessitates attendance in a well-appointed laboratory. With respect to the former, the author considered the subject under three heads; to whom could it be taught? how most easily and practically? when, and at what age?

With regard to the first of these, he would say, from personal experience, that the most elementary and useful facts of chemistry might be taught to all, from the child of six to the man of sixty; but it would be impossible to teach chemical arithmetic to a youth who had not learned common arithmetic.

As to the second, among the readiest means of communicating to a person the facts of chemistry were well-arranged lectures and classes, where the master performed the experiments and the pupil looked on, the latter not being allowed to take part in the manipulation of the experiments. The mind of the pupil was thus free to observe and store up all that occurred. The author drew a great distinction between lectures and lessons. A lecture was a formal discourse, generally to a comparatively large number of persons; while a class lesson implied a much more intimate communication with the master in the way of question, reply, &c. In a class, although the subject might be dry and dull, the master could command an amount of attention from a limited number of pupils; whereas with one hundred pupils, if the lecturer were dull, or the subject too dry, he would have little attention paid to him. All lectures should be interesting as one of their first recommendations, and also attractive. At lectures questions should be rarely asked, but at lessons continually. The plan of giving a printed list of questions on each lecture to every boy, the lecturer to answer all the questions *seriatim* in his lecture, and the boys to answer the questions on paper afterwards, was strongly recommended. The author thought six was a good number for a chemical class, and it ought not to exceed eight. With reference to the age, although it was quite true that many young persons were capable of receiving benefit from experiments on the elementary parts of science, yet it must be confessed that few facts and little real useful information could be permanently lodged in their minds until they were capable of working decimals.

Under the head of chemistry, as a means of general intellectual and practical training, the author asserted that up to the present it had never been properly taught in schools as a means of education. To use chemistry with this object, the student must spend not one hour, but hours at a time in the laboratory. This took up so much time as to be impracticable in the present school curriculum, and required a larger number and a better educated class of men than at present existed as teachers of practical science. The author also contended that laboratory practice was only suited for boys of fourteen years and upwards. The plan never having been thoroughly tried, heads of schools did not believe, from past experience, that there were really the benefits to be derived from chemical study which its advocates maintained. The present method of teaching practical chemistry in schools is by qualitative analysis only; that is, by testing according to the plan laid down in analytical tables. This gives neither accuracy of manipulation, thorough or exact knowledge of the science, nor interest to the pupils, and is therefore almost useless; consequently chemistry had as yet never been practically taught as a means of education.

As a means of intellectual training, mathematics or classics were generally employed, and were greatly in favour; but there was this main distinction between mathematics and practical laboratory work—in mathematics the exact data were all given, in practical chemistry they were not. Thus a student in the laboratory ought to have correct reasoning inculcated, or, as Professor Faraday called it, *judgment*, independent thought on facts, habits of observation, and patience—"to learn to labour and to wait." It is because schoolmasters had hitherto seldom seen a corresponding benefit accrue either to themselves or the boys for the expense and frequent annoyance caused by the so-called teaching of practical chemistry, that this branch of study is in such ill odour. Chemistry could not be taught in the same cut-and-dried manner as arithmetic &c. It required patience, carefulness, thought, judgment, accuracy, and could not be hurried. Practical science was not the accumulation of mere facts, but required the assistance of the eye and touch. From experience the author could bear witness to the fact that masters, university men, who had wished to learn chemistry so as to be able to teach it to boys, were always in a hurry, and could not wait to properly perform their experiments, imagining that there was some royal road to the result. A student when in the laboratory should be made to perform each experiment thoroughly. After the usual experiment (to make hydrogen, for example) had been performed, he should be made to take an atomic proportion of zinc, say 650 grains, and dissolve it, collect all the hydrogen from it, and measure it, evaporate the solution of zinc, and estimate the quantity of sulphate formed. This could not be done at one lesson. On the next occasion he would have his mind brought back to the subject of hydrogen while commencing a new experiment. By the end of the third lesson he would probably have the first experiment finished, the second to continue, and be ready to commence a third. But if from carelessness &c. he did not bring the first experiment to a satisfactory conclusion, he should be made to repeat it until he did. Thus he would for his own sake learn to be careful and patient. It may be objected that a great loss of time takes place in this way. But a fortnight spent in the proper performance of such an experiment, if it be only eventually well done, is not time lost or wasted. At present, boys nominally learn chemistry; but they do so without learning the great lessons that a proper study of chemistry ought to teach. The author proposed, in order to meet the difficulty of the study taking up so much time, that all large schools of, say, 150 boys should have their own laboratory and a resident master thoroughly capable of managing and teaching boys science. That all boys of fourteen and upwards should give up three days in the week, for at least six months, to the laboratory. For small schools there should be a united ancillary establishment in each neighbourhood, for the express purpose of giving boys this practical laboratory education. A proper science teacher ought to be a man of university education, and a thorough practical manipulator. Men would devote themselves to this work if there was a prospect of their earning a livelihood. At the universities natural science was looked down upon and not encouraged. Talk of studying science for the love of her, very few would, and very few could, make the necessary sacrifices, as long as all the money and all the university honours were reserved for classics and mathematics. Thus there was little inducement for the student to study natural science. A man could not be fitted to become a teacher of practical chemistry by reading alone, not by six months' practical laboratory work; the preparation required several years. Heads of schools had no difficulty in getting first-class university men for £300 a year; but these could not teach in the laboratory. Chemical science had never yet had a fair chance as a means of education; nor had schoolmasters generally correct ideas of what the science was capable of doing.

GEOLOGY.

Address by Robert A. C. Godwin-Austen, *B.A., F.R.S., &c., President of the Section.*

The basin of the North Sea, in the physical changes which it has undergone since the commencement of the Kainozoic period, is an area which well repays the study of the geologist. Suffolk and Norfolk, which geologically, as they do ethnologically, form one region, are part of the slope of this basin on its western side; for the North-Sea valley is a true physical depression; the whole secondary series of strata, on one side, dips eastwardly towards it, and rises again above the sea-level, on the opposite side, in Denmark. It is a depression which dates back its origin to some distant time in geological history.

It is to this area that I propose to restrict myself in those observations which, in compliance with established custom, I have to make in opening the meetings of this Section.

The North-Sea depression, in its *hydrographical* features, deserves a passing notice. Compared with its breadth, its depth at present is exceedingly small. There are central portions where there are only twelve feet of water. The "Deep-water Channel" of the charts, which runs parallel with the coasts of Essex, Suffolk, and Norfolk, has a maximum depth of only 180 feet. A change to that amount of depression of sea-level would lay bare the whole of the sea-bed from the coast of Northumberland across to Jutland. A depression of only 120 feet would produce nearly a like result; the new coast-line would in this case run from Flamborough Head to Heligoland and Holstein. There would be an extension of the great Germanic plain nearly to our area. The "Deep-water Channel" alluded to would in either case become the course of the Thames and its tributaries, till it found its way seawards to the west of the Great Banks. To such an extent would this small amount of change of water-level alter the whole physical character of Eastern Europe; and yet this change would be insignificant, compared with those which this very area has repeatedly experienced. There is one other feature presented by the North-Sea basin. A deep submarine trough has been traced, at a mean distance of about fifty miles from the coast-line of Norway; it commences in the meridian of Christiania, and, conforming to the outline of the land, goes north beyond N. lat. 60°. South of the Naze of Norway, there are soundings of upwards of 200 fathoms; beyond they are less, but whether the decrease is progressive is not clear. *Across* the line of greatest depth the change is abrupt. This curious feature in the outline of the sea-bed is just what would have been produced by the subsidence of the whole of the southern portion of the Scandinavian region, together with fifty miles of area around, to a depth of 600 or 700 feet. There are good grounds for supposing that such has been the process; and the geological history of the basin seems to supply the precise date of the subsidence in question.

As a point in physical geography, it was the depression of the Scandinavian mass along the line indicated which produced the channels of the Skagerrach and the Cattegat, and opened a communication from the North Sea into the Baltic depression.

Geologically, some of the later stages or periods of the earth's past history are so abundantly illustrated over the East-Anglian area, it is a field in which there have been so many labourers, as to which, too, there yet remain so many unsolved points, that I cannot help hoping that this Section will follow to some extent the example set by their brethren the geologists of France, at their annual *réunions extraordinaires,* and make local geology a prominent subject of their deliberations at this Meeting.

The points of interest alluded to belong to the great Kainozoic period; indeed it is in this portion of England alone that the complete sequence of change, as it happened in this country, can be followed out; and as the term Kainozoic is what alone I propose to employ, I would explain that it is a Greek compound, signifying "recent living," or indicative of that general period of which the fauna, in

some proportion, is specifically identical, as to forms, with such as are now known to be living in some region or other.

Geological Summary.

Wonderful as the progress of research has been during the last fifty years, still the geologist finds himself greatly wanting when he attempts to sketch out in consecutive order the history of any district, however limited and however simple it may be. He may know that the Nummulitic period was subsequent to the Cretaceous, and also that everywhere an interval of time has separated them; but he does not know, nor has he any means of ascertaining, how long that interval was; and though he may know all the details of the successive conditions of the thick series of depositions exhibited in the London basin, and have satisfied himself of the great extension they must once have had beyond their present area, yet of the process by which so much has been removed he does not know anything, nor of what was being done in any other region of the globe when so much was being undone here. All that can be said is, that here, in the south and east of England, the Nummulitic strata were cut back to a line along which are now Sudbury, Ipswich, and Yarmouth, and that beyond, on the west and north, stretched away the bare chalk hills of Suffolk and Norfolk, northwards still, into the wolds of Lincoln and York.

For our present outline we need not go further back than this in East-Anglian Geology; at the time of the early marine formations of Kainozoic age the British-Islands group was united, as a whole, with a broad European-continental region.

The Kainozoic formations of Western Europe have a striking uniformity in their general history; those of Spain and Portugal—next, those of the Bordeaux basin and of Touraine, with its Breton dependency—finally that of our North-Sea basin, were all indents from the great Atlantic, and, in all, the character of the fauna is Atlantic. It is also noteworthy that in each of these southern and now desiccated sea-basins the fauna is more southern than that now living in the adjacent seas, that the fossil mollusca of the Tagus beds present Senegambian relationships, that so, too, do those of the Lower Bordeaux beds. The Upper Bordeaux beds are Southern and Lusitanian in their fauna, as are those of Touraine and Brittany, and partly so the older Crag of Suffolk, Belgium, and Germany. The southern relations of these several assemblages grow weaker from south to north, whilst in the North-Sea basin distribution from another quarter shows itself in the presence of its many Transatlantic forms. In this there is evidence of a twofold change—First, a set or extension northwards of a marine fauna which in its recognized forms is West-African, afterwards becoming less southern over the same areas; such was the zoological change which the lapse of time brought with it. Next, the areas of these formations are first presented as terrestrial surfaces, then as lateral branches of the Atlantic, lastly as laid bare again; and this process seems to have proceeded from south northwards. The comparison of the whole of the fauna of the Tagus beds with the whole of that of the Bordeaux basin suggests that the first had been wholly laid dry before the other had; so likewise between the Bordeaux basin and that of the Loire.

The Crag-sea waters were expelled from the North-Sea area by the rise of the land on the south of that great bay. The most southern points for the Crag beds in Belgium are now the highest above the sea-level; this elevation decreases till we come to this place, where, if any part of the so-called Norwich Crag or the fluvio-marine be of that age, such estuary beds must have been then much in the same position as they are now, or at the sea-level. On evidence such as this, the North-Sea area, after the period of the early Kainozoic fauna or true Crag, is seen to be passing again to the condition of terrestrial surface.

This old depression of the North-Sea area, as had the other tertiary basins, again became part of the general European land-surface—a northern extension of the Rhine valley; and again the geologist meets with but little guidance as to the details of the chronology of what must have been a period of vast duration. A long list of land animals can be presented which have left their remains here: that some of these ranged over Central and Southern Europe, and included this very

district in the area of their life-period is undoubted; but as to how many of these coexisted, or to what extent they indicate a successive occupation, is still an undecided question.

The "Forest-bed" of Cromer gives a glimpse of what was the vegetation of this period; but here, again, it is more than probable that it must be taken only as the facies of the flora of the last stage of terrestrial conditions antecedent to the next great physical change, rather than that of the whole period.

The whole mammalian fauna, from the Norfolk Mastodon to the Mammoth (*Elephas primigenius*), seems to offer itself as an assemblage of the members of nomad tribes, which have yet to be reduced to order of time. The general condition of Northern Europe was terrestrial for the whole of the tertiary or Kainozoic period; during that time its conditions as to climate passed from warm to temperate and to arctic. To its close belongs the evidence everywhere recurring, and at every level, of its subaërial glaciation and greater elevation.

Just as the Crag and Falun beds come in here, on our East-Anglian district and on the Continent, as breaks in the lapse of tertiary terrestrial conditions, so the accumulations of the great northern submergence come in as a second intercalation; only that the physical change in this case was greater and of a different order. To what this ultimately amounted, is represented on the map of the northern hemisphere*. The arctic basin extended itself as low as to N. lat. 50° by a slow process of submergence from north to south.

Again the northern hemisphere emerged, apparently, in a contrary direction, or from south northwards; again the agencies of ice and snow and excessive rainfall are exhibited, till again, for its general arrangement of land and sea, this immediate district and England generally is presented with the like relations as it had at the period of the Crag-sea.

The general character and the order of change of the Kainozoic period admit of being thus briefly told; but when it is attempted to follow out this change in its details, it is found to be a long and complicated record.

Over the whole of the European area, as yet less accurately traced across the Asiatic, very distinct upon the American continent, there is a region which presents broad expanses of waterworn detritus, sands, and loams, often placed at considerable elevations above present water-levels, which, from their superficial extent, has caused them to be identified with the component members of another detrital group (the glacial drift) peculiar to another area, from which they are distinct as to conditions and mode of accumulation. The conditions indicated are those of low winter temperatures, terrestrial surfaces with a configuration such as the same countries have at present, alluvial and fluviatile accumulations, indicative of torrential and periodic rivers.

A line drawn across the European area, occasionally on one side or other of that of north lat. 51°, defines the north limit of all this class of detrital accumulations of the Kainozoic period; on the south of this all these accumulations have their limits, and the sources of their materials are within the areas to which belong the existing river-systems of the South and Mid-European continent.

North of this line the detrital accumulations are neither local as to composition, nor have they much reference to surface configuration, although such configuration preexisted. Over this area, too, are the indications of low temperatures and broad alluvia. The distribution of the detritus over this area shows that the expanse water was continuous, and was marine. Over one area are the results of a general and uniform submergence; over the other the phenomena are local and alluvial.

Over the British and part of the European area there is a good break in Kainozoic time into præglacial and postglacial,—by the term "glacial" being signified the period of the great extension of the Arctic basin.

This Drift-formation, in one form or another, covers the whole surface of this county, from the sea-level up to the summits of the chalk hills. We have, in Norfolk, evidence of submergence to the extent of 600 feet and upwards. There are other parts of this island where the submergence exceeded this, even in this latitude; so that here the highest land may not be a measure of the greatest

* A map of the northern hemisphere was exhibited to the Section.

amount of submergence. It was a time when the whole of the British-Islands group became submerged, with the exception of a few salient points; and, taking the levels to be derived from these points, together with the general character of the phenomena, we may accept as certain that subaërial glaciation, in all its varied modes of action, had long been at work here prior to that submergence. The change of relative level was not sudden; it proceeded from north southwards; and it is in the north that the amount of the submergence was the greatest.

The Drift of Norfolk has good illustrations of these several sets of conditions, and of the manner in which the phenomena of one period have been modified by conditions which followed. It has been well said that in geological history time is of no object; but in a geological address, such as this, it has its claims; so that instead of dwelling at any length on the general condition of the British Islands at the time of their greatest submergence, I have represented on a map of the northern hemisphere the whole of the area which became submerged, and, for the purpose of comparison, there is along with it another, showing the extent of the Arctic basin at present.

The Drift-accumulations of this county are exceptional in this one respect, that they attain unusual thicknesses. The Cromer cliff, which is wholly of this formation, is 270 feet in height: this is not so much an indication of the lapse of time during the submergence, as the result of position. Situated on the eastern slope of the English central area, towards the North-Sea depression, during the first or subaërial stage, the form and slope of the land would favour the transfer of materials downwards and outwards: in the subsequent stages, the areas of greater depth would receive the greatest amounts of the abraded spoil of the land-areas encroached upon. So likewise during the period of emergence, the transfer of material would be outwards. The most reasonable explanation of the present shallow condition of the North Sea, as compared with its depths when occupied by the Crag sea, is, that it has been filled by the aggregate of the accumulations of the Drift-period.

The former extent of the Scandinavian region is of interest to the British geologist during several periods—during the glacial period, from the spoil that was drifted from it and scattered over our eastern counties.

From early times this region was in the condition of dry land. No beds of the age of the Crag have been met with on its surface; the absence of this formation, which occurs on the coast of Denmark, suggests that the land of Norway then stood at a higher relative level. That this was so is indicated by the manner and extent to which the surface is scored by glacial action, not only down to the present sea-level, but far below it. The deep fiords were occupied by glaciers; they passed over the numerous islands off that coast, which, too, are all scored.

The submarine trough which contours Norway must have been produced subsequently to this greater elevation of the region. The Crag-sea coincided with part of that period of elevation; and its marginal beds in that quarter lay some fifty miles or more from the Norwegian coast-line. The subsequent depression amounted to more than the depth of the trough, inasmuch as around the upper end of the Gulf of Christiania there occur marine beds at elevations of 500 feet above the sea, indicating a total change of level of at least 1200 feet.

Whatever the amount of this former elevation of the Scandinavian land and the precise period of its glaciation may have been, the geological phenomena about Christiania, so carefully described by the naturalist M. Sars, show clearly that the whole has also been much below its present level. The phenomena, as a whole, correspond with what took place over our area, but they are so much more definite that they deserve brief notice as part of the physical history of the North-Sea basin. From an elevation of 500 feet down to 300 feet there is a succession of marginal sea-lines, with banks of littoral and sublittoral shells (Skjælbanker). These have also their deeper water-beds and shells (Mergelleret). These successive lines show that the rise of the land through the 200 feet in question was at intervals.

The marine fauna of this higher sea-level is given first in its littoral, and next in its deeper-water facies. Taken together, we have this result—that all the species are now living, that it is an Arctic-basin assemblage, and not at all that of the neighbouring seas. This is the "glacial-formation" series.

Below the 300-feet level there occurs a belt or interval 150 feet broad, over which "shell-banks" are not met with, below which a second series occurs. The shells contained in these beds differ from those of the higher series in being less arctic. Certain of these characteristic forms have disappeared, numerous boreal shells have made their appearance, together with forms of the Lusitanian region. Altogether this marine fauna approximates to that of the neighbouring seas, only that some members of the earlier or more arctic series linger on.

The subdivision of the East-Anglian Kainozoic series is as follows:—

A. Præglacial; B. Glacial; C. Postglacial.

A. Præglacial.

Crag, in Suffolk, is a local agricultural name for any sandy, gravelly soil; but the early geologists and shell-collectors soon found that it was something more; its very perfect shells were recognized as in part agreeing with those of the neighbouring seas, in part as unknown or foreign. Mr. S. Woodward, in his 'Outline of the Geology of Norfolk,' 1833, has a detailed account of this formation. His own views are admirable; the range of the Crag formation, as he gives it, from Cromer, by Norwich, to the Suffolk coast is nearly exact. Nor did the estuarian character of the formation about Norwich escape him. Apart from this local condition, he considered the Norfolk and Suffolk beds to be "decidedly contemporaneous."

It was not till 1835 that a subdivision of the Crag was proposed by Mr. Charlesworth; and it was amended (in 1838) by the following classification:—

4. Upper Crag of Norfolk and Suffolk—
5. Red Crag.
6. Coralline Crag.

Thus far back Mr. Charlesworth separated the Norwich Crag from that of Suffolk. The Red Crag at Tattingstone, Ramsholt, and Sudbourne was said to overlie a worn and uneven surface of the white or coralline; from this consideration their relative dates or ages was inferred. This nominal subdivision may be said to have been adopted from that time onwards down nearly to the present.

The Bryozoan Crag overlies London clay, and is under 20 feet thick. It is a good division, because it is an indication of a definite range of depths, where the sea-bed was not within reach of surface disturbance, yet where the drifting power was considerable, and having its own proper fauna, of which the Bryozoa form a very large proportion. The examples of this condition of sea-bed occur only in Suffolk, where they are now about 40 feet above the sea-level. Assigning to these beds depths of 40 fathoms, a difference of 300 feet is the least that can be assumed as that of their original, compared with their present positions. It is the lowest condition, or the deepest, of which our English area offers any illustration. It does not occur over any part of Belgium, where the lowest beds above the sea-level belong to the deep-sea deposits of ooze, or to the 100 fathoms depth.

The Red Crag, though a good division for the time when it was proposed, is a complex assemblage, in spite of its small vertical dimensions. Of all that was originally so grouped, a very small portion only (that of one locality) can now be referred to as such, namely, the Crag at Walton Naze; in this alone is to be found an old sea-bed, a marine-life zone, undisturbed since its original accumulation.

The Red-Crag beds of the valleys of the Stour, Orwell, and Deben, though referable to some part of the same general period, are wholly rearranged or *remanié* beds and of the later stages of the Crag-sea; they are, relatively to the Walton beds, very shallow-water accumulations, presenting that diagonal mode of accumulation in varying directions indicative of surface disturbance and tidal movements. Above them, in places, and on the land side of them, are certain thick accumulations of red coarse sands, which have also been referred to the Red Crag, and which at one time I supposed to represent a more marginal sea-zone, the ordinary Red Crag being that condition of sea-bed known as dead-shell sand and gravel. The shell-gravel of Antwerp corresponds with the Red Crag of Suffolk.

Additions were subsequently made, as in the case of the Chillesford Crag of Prestwich, and the Bridlington Crag.

The Norwich, or fluvio-marine Crag, the uppermost of Mr. Charlesworth's classification, was for many years the subject of differences of opinion, as to its value and distinctness as a division; it had also gradually been made to include much more than at first: any bed containing either mammalian and molluscan remains, or even an admixture of fresh- and salt-water mollusca, in any part of Suffolk and Norfolk, had come to be put down as the equivalent of the Norwich Crag.

General opinion seems now to have come round to the view which some geologists had long since taken. Writing in 1865, Mr. Searles Wood states, "the Norwich Crag is not geologically distinct from the Red, but a fluvio-marine condition of the same period." He establishes this in an analysis of the molluscous fauna, such as leaves little doubt as to this point; and the only criticism which is suggested is—may it not have been an equivalent of the whole Crag period? and may not the Yar valley have been a tributary to the Crag Sea, during its whole duration as such?

In Suffolk, the fluvio-marine accumulations at Thorpe, near Aldborough, Wangford, and Bulcham, are considered by Mr. S. Wood to be of the same age as that of Norwich.

The Forest-bed of Cromer (1824), and some other places, to which Mr. R. C. Taylor first called attention, and to which he assigned its true age and position, is one of the most interesting points in Norfolk geology; it is the unmistakeable indication of a terrestrial surface, antecedent to the period of the "glacial-drift" accumulations. This old land-surface, at Cromer, is exposed at the sea-level; but it extends inland, and has been met with at considerable depths in the offing.

The arboreal vegetation buried in these beds comprises the Norway spruce, Scotch fir, yew, oak, alder,—all of them common North-European trees.

What the Cromer coast-section demonstrates is, that by process of change of level a forestial condition of the surface had been brought down to the sea-margin, that the trees had died, and that mud-deposits had formed, partly under fresh, partly under brackish water lagoons.

Subjacent to the "Forest-bed," and covering the surface of the Chalk, is a layer of chalk flints; a like accumulation is seen resting on the Chalk in numerous other places, as in the sections below this city (Holy Cross, Thorpe, &c.), and are all referable to the same agency and period. The flints have been dissolved out of the chalk by the action of rain-water, and left *in situ*; they indicate a long period of subaërial conditions; and their formation is coextensive with the whole duration of those conditions; they are therefore of the same period as the "Forest-bed." All collectors and observers seem now to be agreed upon this, that the Cromer mammalian remains are referable to this particular surface.

B. Glacial.

More recently the Norwich sections have been subjected to a closer examination; and according to Mr. J. E. Taylor (1867) these admit of a twofold division: the upper is a coarse and rubbly accumulation, with well-rounded pebbles of flint; the lower consists of finer sands. A band of white cross-bedded sand intervenes. Such a change in the character of successive beds would not, by itself, have been of much importance; but zoologically the differences they present are much more significant.

The fresh- and brackish-water forms, which long since gave the Norwich Crag its fluvio-marine character, occur only in the lower division; in this, too, the proportion of littoral species of marine shells is greater; and here also are found all those forms which are supposed to be extinct.

The upper division has its peculiar forms, such as *Modiola modiolus*, *Astarte compressa*, *A. sulcata*, *A. elliptica*. Other shells are more abundant which in the lower are scarce; here they occur as if in their "life-zone," instead of as single valves, worn and broken—such as *Tellina obliqua*, *Astarte borealis*, *Venus fasciata*, *Cardium Grœnlandicum*, *Cyprina Islandica*, *Rhynchonella psittacea*.

It is only in respect of one shell (*Tellina obliqua*) that the forms of the upper division have not been recognized as living; and with respect to distribution, the northern facies of the upper assemblage is more strongly marked than that of the lower lastly, they indicate a somewhat greater depth of water.

Mr. S. Wood, jun., admits this division; "the upper bed at Norwich," he says, "is the Chillesford shell-bed."

Chillesford Crag.—In 1849, Mr. Prestwich made known some marine beds in the parishes of Iken and Chillesford, either yellow sands or laminated micaceous clays. At Iken these beds are superposed upon a worn surface of the older or Bryozoan Crag. There is no such direct evidence as to their relation to the Red Crag; but there is no doubt that they are unconformable to both divisions.

These beds are in striking contrast to the true Crag, in respect of their composition and the condition of the shells they contain; they were tranquil depositions, the bivalves at every place constantly exhibiting the two shells in contact, and in the positions in which the animals had lived. With respect to this fauna, 23 species only were met with—4 Gasteropods and 19 Acephala. Mr. S. Wood recognized the Arctic character of the assemblage, and considered the beds posterior to the Red Crag, probably the equivalents of the Norwich. The agreement with the Bridlington Crag was not very close, there being only six or seven species in common.

Differences of opinion as to detail, both of facts and inferences, might be cited, as is well-known to those geologists who have attended to this very complicated portion of the geological record; but thus much seems to have been ascertained, that the so-called Chillesford Crag is rather a subordinate member of the marine glacial period than an upper member of the Crag, and that it is referable to a time when the climatal conditions, as indicated by the marine mollusca, had undergone a great change.

Bridlington Crag was a name given to a set of marine clay-beds occurring at that place, about 30 feet thick; they overlie an accumulation of chalk flints derived from the subjacent chalk.

Mr. S. Wood, in his Monograph, included these beds in the Crag, and considered them the equivalents of the Norwich Crag (1855).

I am not aware that the fauna of these beds attracted any particular attention till Mr. S. P. Woodward prepared his general list of the Norwich-Crag accumulations for Mr. Gunn's essay. In 1864 he undertook a fresh examination, not from lists, as before, but from original specimens from Mr. Bean's and Mr. Leckenby's collections; this led him to the unexpected result that the Bridlington Crag could no longer be considered an equivalent of the Norwich Crag. The list of marine testacea had been increased to 64 (or by more than 20); of these, 35 are met with in the Norwich Crag, whilst 29 species (or one-half) are now living in seas north of Britain, the proportion of Arctic shells in the Norwich Crag being only one-sixth.

Mr. Woodward next compared the Bridlington fauna with that of the Clyde beds belonging to the close of the "glacial period," and with this result, that they differed very nearly as much from these as they did from the Norwich assemblage; they must therefore be separated from the Crag series.

The Bridlington testacea are more indicative of Arctic climatal conditions than any assemblage in or about the British Islands. As an assemblage, it is wholly recent and living, and marks a stage in the northern submergence during the glacial period, when the Arctic-basin marine fauna had extended itself over our seas.

Shells peculiar to Bridlington.

Fusus gracilis, var. ventricosus.	Dentalium Tarentinum (entale).
Trophon clathratus, *L.* (Bamffius).	Montacuta bidentata.
Natica occlusa.	Cardita analis? (borealis?).
—— Bowerbankii.	Astarte borealis, var. semisulcata, *Leach.*
Trichotrophis borealis.	—— mutabilis.
Turritella erosa, *Couth.* (clathratula).	—— crebricostata?.
Margarita elegantissima, *Bean.*	
Cimoria Noachina.	

The Bridlington beds seem to correspond most nearly in age with those which, in Norway, M. Sars has distinguished as his glacial formation.

Mr. Trimmer candidly admits that, when engaged in the "Geology of Norfolk"

for the Royal Agricultural Society (1847), it was the adoption of a theory guiding his observations that enabled him to disentangle and harmonize all that mass of confused materials (Drift) which till then had so perplexed him; "each part then soon fell into its appropriate place." In this case, fortunately, the adopted theory was right, namely, submergence and emergence—that the accumulations of the erratic group indicate a long period of accumulation over a terrestrial surface, followed by denudation as it rose again. For the whole of the period and its products, he proposed two groups of Drift—a lower and an upper. He seems to me to have recognized certain distinctive characters in the Lower Drift, which are the indications of the different conditions of accumulation concerned, such as "the masses of fragmentary chalk, with little or no admixture of other matter," "angular fragments, very slightly water-worn," and, on the other hand, the "detritus from greater distances;" the transfer of this chalk material in the direction of Cromer had not escaped him.

Mr. Searles Wood, jun., had proposed for the "Drift or Glacial" series of the upper Kainozoic period an upper and a lower; he subsequently subdivided the lower, whence resulted:—

	feet.
1. Upper Drift, or Boulder-clay, maximum thickness....	160+
2. Middle Drift, maximum thickness	70
3. Lower Drift (boulder, till, and contorted beds of Cromer)	150+

The Lower Drift immediately overlies the Chalk, except near this place, where it has what has been designated as the "Norwich Crag" at its base, the inland facies of this division being a mass of merely remanié chalk rubble, without any admixture of other materials; this facies does not extend east of Norwich. Beyond and on to the coast the Lower Drift is of sand; above, on the coast section, is a blue till with boulders, horizontally bedded, passing up into very contorted beds. These lower sands west of Cromer contain the débris of the underlying Lignite beds. In the case of the inland, as of the coast-line facies, the character of the accumulation is immediately dependent on the subjacent beds. When we bear in mind that previously to the accumulation of this Drift-series the boundary line of the Nummulitic formation by Sudbury and Ipswich had been well defined, and consequently that High Suffolk and Norfolk presented a range of bare chalk hills, we are prepared to adopt the supposition of Mr. S. Wood, jun., and refer this division of the series to the agencies of subaërial glaciation.

C. Postglacial.

In the Nar valley, which joins the Ouse at Lynn, is met with a well-known set of marine depositions of this age. They extend some nine miles along its course, and occupied what must have been a creek at the time when the whole of the Bedford level was sea—an inland extension of the Wash. Mr. Rose called attention to this stage of the Kainozoic series in 1836, and assigned it to its true position. This deposit, which is 40 feet in thickness and 60 above the present sea-level, contains 27 species of testacea, all of which are also North-Sea shells.

These subjects have engaged many speculative and ingenious minds, from the middle of the last century, down to those now actively at work here—such as Arderen, William Smith the father of Geology, the Taylors, Robberds, the Woodwards (of whom four generations), Clarke, Mitchell, Trimmer, Gunn, Osmond Fisher. But I should be wanting to the place in which we are now met, wholly unworthy to fill this chair, wanting to the great subject which assembles so many here, wholly forgetful of my own obligations, if I were not mindful that Norwich may claim with Cambridge joint ownership in the Woodwardian Professor—the Rev. Canon Sedgwick.

Notes on the Fossils from the Old Red Sandstone of Kiltorcan Hill, County Kilkenny. By Wm. Hellier Baily, *F.L.S., F.G.S., &c.*

With reference to the plant-remains, Dr. W. P. Schimper has communicated to me some important information. He remarks that the fructified leaves of *Cyclo-*

pteris Hibernica show that this fossil fern belongs to the family of Hymenophyllæ, forming a peculiar genus, to which he gives the name of *Eopteris*.

The species of *Sagenaria* he names *S. Bailyana*. In the fruit of this species, which differs from *S. Veltheimiana*, the scales are extremely long, and nearly subulated. On some specimens very large and distinct sporules were arranged at the bases of the scales; this he considered very remarkable, as no other species, of which the fruit is known, have such large sporules, a proof, as he remarks, of inferiority of the plant, probably the oldest of the genus.

In the last collection of fossils made at this place by myself and the fossil-collectors of the Geological Survey, parts of a crustacean, including the chelæ or pincers, were obtained, presenting clear evidence of the existence of *Pterygotus* amongst this assemblage. This species I propose to name *P. Hibernicus*. The discovery of these characteristic portions of a genus, which appears to have preceded *Eurypterus*, is of considerable importance, both stratigraphically and as serving to explain the more exact relationship of specimens formerly obtained from this place, and doubtfully referred to the latter genus, but which will, I believe, be found to be identical with *P. Hibernicus*.

The fish-remains hitherto discovered are, for the most part, in the condition of detached bones and plates or scales, and are therefore necessarily difficult of determination. *Glyptolepis* and *Coccosteus* are the prevailing forms; there are others, however, which require study and additional specimens for their elucidation. It is hoped therefore that further explorations at this important fossil locality will throw considerable light upon the fossils of the Old Red Sandstone.

On the Molluscan Fauna of the Red Crag. By Alfred Bell.

The results of a critical comparison of the shells of the different crags are considered by the author to justify him in the following conclusions:—

That the series of deposits constituting the Red Crag proper commences at Walton-on-the-Naze, and *does* not extend *further* north than Chillesford, where it appears as the base-bed of the pit under the church.

That the molluscan fauna contained in this area *lived* in the Red Crag seas, and are *not* derived from the débris of an older formation (except in a very few cases).

That the beds containing these shells were deposited in quiet waters, and

That the proportion of recent forms is about 65 per cent. (exclusive of land and freshwater shells).

In support of these propositions it is shown that the lowest Red Crag deposits, *i. e.* those at Waldringfield and Walton-on-the-Naze, while the nearest in their relations to the preceding formation, containing such characteristic Coralline Crag shells as *Gastroma laminosa*, *Artemis lincta*, *Cardium decorticatum*, *Voluta Lamberti*, *Fusus consocialis* and *alveolatus*, *Terebra inversa*, *Eulima polita*, *Cerithium inversum*, *Pyramidella læviuscula*, and others, are marked by the introduction of at *least* fifty new forms.

Of the 400 species found in the Coralline, not more than about half range upwards to the Red Crag, and the greatest diversity in their respective faunæ obtains where, as at Ramsholt and Sutton, the two formations are seen in juxtaposition. The small solid *Pyramidella* may serve for an example. Abundant in the White Crag at Sutton, it is *altogether absent* in the Red Crag at the same place.

The following short list will suffice to show the difference in the characteristic shells in the older and newer Red Crags, most of the abundant forms of the lower beds (Coralline Crag and earlier Red) being altogether absent, or but sparely represented in the upper horizon, and also the reverse.

Older Red Crag of Walton and Waldringfield.

Coralline Crag shells as already quoted: *Artemis exoleta*, *Mactra glauca*, *Tellina Benedenii*, *Cardium Parkinsonii*, *Nucula lævigata*, *Cypræa angliæ*, *Nassa elegans* and *reticosa*, *Purpura tetragona*, *Buccinum Dalei*, *Cancellaria coronata*, *Actæon* (var.) *noæ*, &c.

Newer Red Crag of Butley and Ramsholt.

Pecten gracilis, *Mytilus edulis*, *Nucula Cobboldiæ*, *Yoldia myalis*, *Cardium græn-*

landicum and *angustatum*, *Tellina prætenuis*, *Saxicava norvegica*, *Fusus altus*, *antiquus* (dextral form), and *norvegicus*, *Trophon scalariforme*, *Buccinum cyaneum*, *Purpura lapillus*, *Mangelia rufa*, *Admete viridula*, *Ringicula ventricosa*, *Littorina littorea*, *Trochus tumidus*, *Scalaria grœnlandica*, *Natica clausa*, and (var.) *occlusa*, *helicoides*, and *catena*, *Actæon tornatilis*, and *Conovulus pyramidalis*, &c.

In the newer horizon at Butley, the vicinity of land is apparent, this marine bed having yielded to the author *Pupa marginata* (2), *Planorbis complanatus* (2), *Limnæus pereger* (1), *truncatulus* (1), and an unfigured? form.

The quiescent nature of the Red Crag seas may be judged from the exquisite state in which every species (not specimen) may be obtained, and the number of perfect bivalves to be obtained *in situ*, as *Terebratula*, *Mytilus*, *Cardium angustatum*, and *edule*, *Astarte*, *Gastrana*, *Solen*, *Mactra*, and *Pholas*.

A list of all the species of Red Crag shells known was appended to the paper.

Recent Geological Changes on the British Islands. *By the* Rev. James Brodie (*Monimail, Fifeshire*).

In this paper the author arranged his observations and conclusions under the following propositions:—

1. *There has been no elevation of the coasts of Britain in consequence of subterranean agency since the time of the Roman occupation.*—St. Michael's Mount in Cornwall is now, as it was in the time of the Greek historian, an island at high water, and a peninsula at the ebb. The remains of Roman buildings, roads, embankments, and fortifications which have been discovered in Kent, in Norfolk, in Lincolnshire, in the valley of the Forth in the neighbourhood of Edinburgh, and of Stirling, and on the other side of the island in the valley of the Clyde in Lanarkshire, show that the level of the sea and land, at the time when they were formed, was the same as it is at present. On the north-east coast of Scotland, rude sculptures on rocks, kitchen middens, and other traces of the prehistoric races who were contemporary with the Romans, are found in such situations as show that there has been no alteration of the coast-level since they were formed. We therefore conclude that there has been no elevation of the coast of Britain, either sudden or gradual, since the Roman occupation.

2. *The last elevation of the Scottish coast was sudden.*—In the valley of the Forth, near Stirling, several skeletons of whales have been found imbedded in a bed of clayey loam, which is from 15 to 20 feet in thickness. The bones are so entire, and lie in such regular position, as clearly to prove that they must have been enveloped in the clay that surrounds them, while the ligaments that bound them together were still entire. They cannot have been exposed for any length of time to the action either of the water or of the air. If the elevation of the coast had been slow and gradual, as soon as the bed of loam came to be exposed to the action of the wind and wave, it would have been washed away, and the skeletons thus left unprotected, the bones would have been weather-beaten, broken, and scattered. A similar argument may be employed in regard to some shell-beds which have been found in the same neighbourhood. These beds lie sometimes in loam, sometimes in sand. They are from 5 to 15 feet above high-water mark. The shells are numerous, and remain in the same position they occupied when the animals they contained were alive. In the valley of the Clyde, near Glasgow, similar beds of shells are found. In that quarter also a number of ancient vessels have been found imbedded in loam. Some of them were 20 feet above high-water mark. These vessels evidently owe their preservation, like the Stirling skeletons, to the clay that surrounded them, and we conclude that, like them, they must have been suddenly elevated.

3. *The extent of this elevation was between* 30 *and* 40 *feet.*—The surface of the bed of clay in which the skeletons are imbedded, in its higher parts, is 28 feet above ordinary high-water mark. As that surface must have formed the bottom of the estuary before the elevation took place, we cannot estimate its amount at less than 30 or 40 feet.

4. *This elevation took place some two thousand years ago.*—Among the vessels

found in the valley of the Clyde there were two which were artistically constructed, and had the appearance of ancient galleys. In one of the vessels was a plug of cork. We may therefore conjecture that these were trading-vessels from some of the Carthagenian settlements in Spain; and we are led to suppose that the date of the catastrophe that destroyed them was some centuries before the Christian era.

There are indications that some time previous to this elevation the coast of Scotland must have been subject to earthquake tremors, like those that recently occurred at Tortola in the West Indies, but of greater violence and extent. There are also evidences of a succession of elevations and depressions of a remarkable kind that must have previously taken place.

While the coasts of Britain exhibit no trace of subterranean agency since the time of the Roman occupation, previous to that date they must have been subject to very violent and extensive convulsions.

On the Western Asia Minor Coal and Iron Basins, and on the Geology of the District. By Dr. HYDE CLARKE.

The author describes the extensions of the basins first discovered by him, and which includes an area of 120 miles by 120, extending over the districts of the Mæander and Hermus. Dr. Clarke, referring to his former observations on the extension of mica-schist across the Bosphorus into Europe, suggests the possible connexion of the Hurbklea coal-mines and the Asiatic shore of the Black Sea, and the lignite formations on the European shore. The latest discoveries in the main basin are of coal at Birdik in the upper course of the Mæander, and that at Kayejik in the district of Chiordes, illustrating the easterly extension. Dr. Clarke expresses his firm conviction that this old gold district of Pactolus will be found a productive field.

On the Skeleton of a Fossil Whale recently exhumed on the Eastern Coast of Suffolk. By EDWARDS CRISP, *M.D.*

The skeleton of this whale (the first perfect skeleton found in England) had recently been exhumed by the author; it was found in the Chillesford clay, about 10 feet below the surface. It was 31 feet in length; measurements, drawings, and models of all the bones, as they were *in situ*, were taken. Many of the bones, the vertebræ especially, were so soft that they fell to pieces on removal; but the whole skeleton, the author said, could readily be partly restored by means of the clay models and plaster casts.

Dr. Crisp had examined and measured all the skeletons of modern whales in the British Museum, and in the Museum of the College of Surgeons, and he came to the conclusion that this was a new species of *Balæna*. A careful comparison had been made of the tympanic bones of this whale, and the same bones of many fossil and modern whales, and they differed from all at present examined. Fossil shells, impressions of shells, and fishes' bones were found in the clay around the skeleton. Very careful investigations were needed, and much work had to be done, the author said, before accurate conclusions could be arrived at. The paper was illustrated by numerous drawings; and some of the vertebræ, portions of the ribs, and the tympanic bones were exhibited.

On the Parallelism of the Cretaceous Strata of England and the North of France, with those of the West, South-West, and South of France and the North of Africa. By Prof. HENRI COQUAND, *of Marseilles. Translated by* JOHN WICKHAM FLOWER.

In this paper the author observes that the divisions of the Cretaceous beds, which were originally established by English geologists, and which have been generally accepted on the continent of Europe, are, in fact, altogether insufficient, in a great measure, and inapplicable as regards any other district than England and the north of France. Thus, for example, as we approach the west of France

extensive beds of limestone and sandstone, characterized by *Ostrea biauriculata* (and which are entirely wanting in England and the north of France), known as the *Grès du Mans*, are found interposed between the base of the Lower Chalk and the highest beds of Chalk-marl.

Proceeding towards the Pyrenean basin more important modifications occur. The *Grès du Mans* is much more largely developed, and comprises a great abundance of *Rudistes*. Above this layer are found the marly beds of the Lower Chalk; and above these again, the *Angoumien, Mornasien*, and *Provencien* strata, equivalent together to a thickness of 2000 feet.

In the basin of the Loire another horizon is found, which, in its turn, supports a solid limestone abounding in other species of *Rudistes*; and with this, the *Craie moyenne* of the south-west and south of France terminates.

The author then proceeds to describe the Upper Chalk as composed of four distinct layers, each characterized by a distinct fauna, and neither of which are met with in England or in the basin of the Seine. In the west of Provence these beds are largely developed; and M. Coquand has given diagrams and lists of the characteristic fossils, which seem to differ essentially from those found in similar beds elsewhere.

M. Coquand then gives a description of the Upper Chalk of Provence, dividing it into *Coniacien* (ferruginous limestone), *Santonien* (of which the upper portion is fluviatile), and *Campanien* and *Dordonien*, both consisting of freshwater limestone, with eighteen distinct beds of lignite, and attaining a thickness of from 1500 to 1800 feet. The *Campanien* and the upper part of the *Santonien* furnish large quantities of coal; and, indeed, Marseilles and the surrounding district are entirely dependent upon these beds for their supply of this mineral.

The cretaceous beds of Algeria are next described, and their correspondence, as regards their fauna and position, with the Provençal strata before described is shown; and after observing that by a comparison of Algeria with Provence, Provence with Charente, Charente with Sarthe, Sarthe with Paris, and Paris with England, we shall be able to recognize the various links of the Cretaceous system, M. Coquand suggests that the divisions hitherto recognized by English geologists are altogether inadequate to indicate the true character of the chalk, and that if a general classification of these strata were now to be established, the preference ought to be given to Provence, on account of the facility of finding those divisions larger and more numerous, and, in short, presenting more classical types.

On the Formation of certain Columnar Structures. *By* J. Curry.

On the Genus Clisiophyllum.
By Dr. P. Martin Duncan, *F.R.S., F. and Sec. Geol. Soc.*

Great numbers of specimens of several species of this genus abound in the Lower Carboniferous limestone of the Scottish coal-field at Beith, Ayrshire, Lesmahagow, Lanarkshire, Bathgate, Linlithgowshire.

Mr. J. Thomson, of Glasgow, whose photographs of sections of Carboniferous Corals were exhibited at the last Meeting of the Association, has forwarded me about 200 fine specimens, carefully cut in sections, and in excellent order.

A careful examination of these has enabled me to arrive at the following conclusions:—Dana, the great American zoophytologist, originated the genus, and M'Coy, following Dana, gave new species of it to science, and had sections of his types lithographed in Sedgwick's celebrated work on the Palæozoic fossils.

Milne-Edwards and Jules Haimes retained Dana's name *Clisiophyllum* in their description of the genus in the Introd. Pal. Soc., in their Des. des Pol. des Terrains Palæoz., and in their Hist. Nat. des Corall. But they have added a most important structural peculiarity to the genus. Doubtless they had better specimens than Dana and M'Coy; for nothing can be more evident than the existence in the axis of the corals of the genus of a great lamella, ending at the bottom of the calice in a prominent ridge. The ridge was noticed by the previous authors, but not the lamella. Yet this lamella determines the peculiar construction of the central parts of the coral. M'Coy, in the description of one of his species, says that a

large septum exists across the central area, but in another place, and in his drawings there is nothing of the kind.

Those palæontologists who study from M'Coy are therefore at a very great disadvantage. The correctness of the views of Milne-Edwards and Jules Haimes is beyond a doubt, and *Clisiophyllum* of Ed. and H. is thus readily separable from the closely allied genera *Aulophyllum* and *Cyclophyllum*. The genus is interesting, because the apparent prolongations of the septa over the central boss to the columella are indications of the pali which abound in many Mesozoic genera, and also because it is closely allied, from its minute structure, with the well-known compound forms of *Lonsdaleia* and *Lithostrotion*. This alliance was asserted by Dana. The specimens prove that, although they may be arbitrarily divided into three species, still the gradation of structure between the types of these species is perfectly shown in some of the numerous examples. Moreover, the variation in some of the structures, which are generally considered sufficiently stable to be safe guides in species-making, is immense. In fact no better proof can be given that a species is the sum of a greater or less amount of variation, instead of a fixed and definite matter, than that afforded by these Scottish corals.

The specific differentiation must be decided, not by the shape, or size, or septal number of the corals, but by the *size of the central area*, the obliquity, straightness, and quantity of the endotheca generally, and the number and direction of the septa which cover the central area.

On the Denudations of Norfolk. By the Rev. O. Fisher.

The author first called attention to the denudations upon the land surface, stating that a certain amount of the fine material was being carried into the rivers, and by them deposited at the heads of the broads or in the sea. This denudation by pluvial action was undoubtedly greater where the land was under the plough than it would be otherwise. Upon the coast the sea was reducing the solid surface to a uniform level. Where the land was high it cut away the bottoms of the cliffs, which then foundered down, and the fallen matter was in its turn carried off; and where it was low the general contour of the coast was being continued by sand dunes or "Marram Hills;" so that where the end of a valley was submerged, its bottom was being raised seaward, and reduced to a uniform level and continuous coast-line. But when the waves had played their part, the action of the sea was not ended. As the sea cut further into the land, the ground laid under water became subject to the action of tides, so as to be kept, on the whole, at a uniform depth for a given distance from land. If the waste of the shore was prevented by artificial means, the sea was found to deepen rapidly, and the inclination of the bottom from the shore to be increased. This marine action, if considered, did not appear possible to give rise to any very great inequality of surface, but, on the other hand, it must tend to reduce those already existing.

All great inequalities of the sea-bottom must either have been caused by the land having become submerged more rapidly than the sea had time to move its coast-line, or else by elevations and depressions taking place beneath the ocean, or, in a few instances, by powerful currents confined by local circumstances to a narrow course. Since the tides deepen the sea below the level to which the waves act upon the coast, it must follow that the harder rocks must be lowered more slowly than softer ones, and shoals be formed. It was to such a denudation as that just described that the form of the surface of this county might be supposed to be due at the period preceding the deposition of the Crag. It might be safely supposed that the sea-bottom at the period of the Crag consisted of a shoal bottom of chalk, nearly level on the eastern side of our area, while the same stratum rose as dry land to a considerable elevation towards its central and western portions. But there was no distinct indication of the position and ancient coast-line of the Crag sea, though, no doubt, it extended further inland than Norwich, Horstead, and Coltishall; indeed the author saw no reason to doubt that the remnants of ferruginous shelly gravel adhering to the surface of the chalk on the beach at Lower Sherringham belong to it. The appearance of the chalk at Bungay and of the Upper Norwich Crag at Aldeby, near Beccles, would place the junction of the two deposits somewhere between Beccles and Bungay.

There were no data for determining the coast-line of the Crag, but it was probably a line of cliffs extending in a direction somewhat paralled with the present eastern coast of Norfolk, and about twenty miles westward of it. At Yarmouth, where the London clay covered up the chalk, a different condition of things must have obtained. Indeed, in early postcretaceous times, there seems to have been a depression of erosion in course of the valley of the Waveney and the Little Ouse. There is no evidence that the sea of the Crag period occupied any part of the present estuary of the Wash. It is probable, on the other hand, that the chalk must have extended considerably to the westward of its present escarpment.

Immediately upon the chalk at Thorpe, where the Crag rests upon it, is a thick bed of angular flints, which appears to be the accumulated result of the removal of the chalk intervening between several successive layers. It is amongst these flints that numerous bones, teeth, and tusks of Mastodon and *Elephas meridionalis* and other mammalia occur. The author's opinion was that the chalk to which these flints are due was removed by the erosion of currents, which were not strong enough to remove the flints. To account for the bones found amongst these flints there was the alternative that the chalk formed a land surface on which bones were left, the flints being accounted for by subaërial solution of the chalk. After discussing the difficulties which this supposition raised, he proceeded to consider the succession of events subsequent to the period of the Crag. As to the Chillesford clay, the author recanted his formerly published view (referred to by the President of the Section), and added that, although he agreed with Messrs. Wood regarding the sequence downwards from the Chillesford clay to the Crag, whether red or fluvio-marine, he did not think that its position relative to the Forest-bed and glacial series above was yet satisfactorily made out, and expressed an opinion, rendered probable by the occurrence of whales' bones in both, that it might be identical with the soil in which the preglacial Forest-bed was rooted.

The author then traced the course of events until the close of the glacial period, adopting Mr. S. V. Wood, jun.'s views of their division into "Lower," "Middle," and "Upper Drift." He showed that the contortions in the lower drift were chiefly due to the precipitation of large masses of gravel, chalk, &c. upon a soft bottom, and proved that Mr. Trimmer's supposition of the sinking of blocks of ice was a necessary result of the thawing of masses containing a portion of earthy matter; and he explained the anomalous position of patches of shelly gravels, containing abundance of *Tellina solidula*, by supposing them portions of frozen beach deposited unthawed at the bottom of the sea.

The author subsequently referred to the denudations by which the present contour of the surface has been formed. He thought that we must look to the action of the sea for the removal of the greater part of the strata which have disappeared, but to subaërial action for the present contour; and, referring to his published views, attributed the latter to the action of land-ice. To this he considered due the peculiar disturbed condition of the first three or four feet of almost every section, and the furrows often extending to more than twice that depth, filled with materials from higher ground in rear. He adduced also the recurved edges of vertical slate-beds, to be met with even on level ground, as evidences of the same action.

The author then remarked upon some of the peculiarities of the surface-contour of Norfolk, especially its Broads and Meres, and suggested that they had probably a glacial origin, and arose from the occupation of the surface hereabout by ice at a later date than in other parts of England, as now the January Isothermal of 32° F. approaches nearest to this part of England. It must be premised that a low mean temperature is necessary for the production of land-ice, although not for floating ice, which is carried by currents into temperate regions. He likewise attempted to explain the remarkable flat valley occupying the watershed at Lopham Ford by glacial denudation.

On the Skull and Bones of an Iguanodon. By the Rev. W. Fox.

The object of this paper was to show that the author has discovered a new species of Iguanodon. In proof of this he exhibited a skull, which, from the character of its teeth, there could be no doubt belonged to an Iguanodon. The skull,

he argued, was too small to belong even to the newly hatched young of the species *I. Mantelli*. Besides this, the skull showed that his new species had teeth in the front of the mouth of a conical and prehensile character, which the well-known species has not. The author further stated that he has discovered several other almost perfect skeletons of Iguanodons similar in size to that to which the small skull belonged; and that all these remains came from different parts of one and the same bed in the Wealden formation near Brixton, in the Isle of Wight. The number of these small specimens, unmixed, as it seems they were, by bones of larger individuals, he assigns as another reason for regarding these bones as indicative of a new species. It appears also that this new species had four toes in the hind foot, whereas (if Owen has made no mistake) the large Iguanodon had but three. Again, the new species, if it be such, has its iliac bones much more expanded and bird-like than the same bones in *I. Mantelli*. And lastly, the author argued that the bones of these small specimens cannot have belonged to the young of the *Iguanodon Mantelli*, because he has specimens where he can see *in situ* ligamental bones stretching between the neural spines of the vertebræ; for, so far as we know, the ligaments of animals never become ossified till they have attained to considerable age. It appeared also from this paper that the author had made a vast accumulation of Iguanodon bones and teeth of various sizes, and from these he is led to believe that not only is the small Iguanodon in question a new species, but that there were probably several species of the Iguanodon family existing at the time when the Wealden formation was being deposited.

On the inapplicability of Fossil Plants to support the Theory of Gradual Transformation. By Professor Göppert.

Artificial Rocking-stones, an experiment. By W. R. Grove, *F.R.S.*

Some short time ago, during an excursion in Cornwall, the author's attention was naturally directed to rocking-stones, and those approximations to rocking-stones which are seen in the granite where it is exposed to the action of heat and cold, air and water. It need hardly now be contended that rocking-stones are natural results, and not superposed on their pedestals, as was once believed, by the hand of man.

Throughout the greater part of the granitic rocks of the west coast of Cornwall formations are to be seen approaching in character to rocking-stones or to discoid piles like the Cheesewing.

If we suppose a slab of stone of a parallelopiped form lying on another, both having flat surfaces—or, in other words, such slabs as are formed by fissures in horizontal and perpendicular directions, which are common in exposed granite rocks—the attrition and disintegration produced by changes of weather, of temperature, &c., would necessarily act to the greatest extent at the corners, and next to that at the edges, because these parts expose respectively the greater surfaces compared with the bulk of the stone. This would tend to round off all the angles and gradually change the rhomb, more or less towards an oblate spheroid. This would account for the Cheesewing &c. But then, it may be asked, why should this process gradually work on to a rocking-stone? in other words, why should the last unworn point, points, or line be in the line joining the centre of gravity of the upper stone with that of the earth?

Such an accident, it may be said, might happen, but the chances are almost infinity to a unit against it. Not so. Assume the wearing away between the slates to reach a point which is not in the line of centres of gravity: the upper stone would then fall on one side, leaving the unworn point most exposed to climatal and probably to electro-chemical action from the water lying in the angle of the crevice, evaporation being less rapid there than at other parts. This point would then be worn away and the stone would fall back a little, then fresh action upon new surfaces, another oscillation, and so on. The effects above explained as taking place by steps would in fact take place by insensible progression. Assuming this process, unless there be some interfering action, it becomes not impro-

bable that the last point or line worn away would be the point or line on which, from its being in the line of centres of gravity, the upper stone would rock.

After seeing the great Logan Stone near the Lands End, so many other approximations to rocking-stones along that coast were traced that it seemed proved, as far as could be expected on such a subject of inquiry, that this was a correct theory. If this view were true, it seemed probable that the operations of nature might be hastened so as to produce artificially (if such a term may be used) the rocking-stone results. A very little thought suggested the experiment. Two parallelopipeds of iron, which had been made for keepers of magnets, were taken, similar, but that one was twice the length of the other. The shorter was superposed on the longer, and both immersed in sulphuric acid diluted with three times its volume of water. Some nitric acid was added at first to hasten the corrosion. The liquid was changed from time to time as it became nearly saturated, but without changing the position of the iron. At the end of three or four days the pieces of iron were taken out, washed, and examined, when the upper one was found to be a perfect analogue of a rocking-stone, so delicately balanced on two points that it could be made to rock by blowing on it with the mouth [result shown].

It was observed in this experiment that the iron rocked only in one direction. Such is the case with the great Logan Stone, and possibly with the greater number of rocking-stones. It is obviously more probable that a stable equilibrium should be attained on two points than on one. A specimen capable of rocking or spinning on one point has not yet been obtained [approximation to this shown by two zinc disks, and explained]. If the surfaces of the slates be in such close contact that there is not room for circulation of the saturated liquid, a formation like those near the Cheesewing will be effected; or if a number of disks or slates be superposed and the lower ones more exposed to the weather, so as to catch the dripping and drifting water from the upper, we should get a formation exactly like the Cheesewing, which may be called an incipient compound rocking-stone, in that each slab is worn away at the edges, and the lower ones much more than the upper, so that, if left alone, which it will not be, and if it does not topple over too soon, which it probably will, it might well end in a rocking-stone. Very possibly it may rock now in a great storm.

On the Alternate Elevations and Subsidences of the Land, and the order of Succession of Strata in Norfolk and Suffolk. By the Rev. J. Gunn.

This paper is supplementary to that read by the author at the Meeting of the British Association at Dundee on the "Periodic recurrences of Oscillations of Level and Changes of Climature," which may be said to have reached their maximum. Some of a more limited and local operation, which appear to have taken place during the progress of one elevation or subsidence to another, formed the subject of this paper. Among these the author particularized an upheaval which took place during the formation of the river-valleys, and may be seen at Lophamford in Norfolk. There the singular phenomenon of a watershed presents itself in the lower part of the valley, from which watershed the Waveney and the Little Ouse take their rise. A road traverses the valley descending from the high land of South Lopham, and leading to the high land on the opposite side in Suffolk. From either side of this road the water rises which forms, or rather is the commencement of these rivers, which, together with a few feet of the causeway, form the boundary of Norfolk and Suffolk. It is evident that, had the watershed been originally on this spot, the upper part of this valley (about fifty feet) could not have been excavated, and that the present arrangement is due to an upheaval, which caused the water, which had previously flowed in one direction, to flow to the east and to the west on either side of the watershed. A magnificent bed of valley-gravel near the ford, on the Suffolk side, attests the power of the original stream, which is now divided and dwindled to a small rill by this oscillation of levels.

The author next referred to the Forest-bed on the Norfolk and Suffolk coast and the laminated series overlying it, observing that no deposit more strikingly exhibited the effects produced by alternate elevations and depressions than the Forest-bed. It was formed, in part, at least, in a basin of chalk, which was covered with

a mastodon-bearing bed of angular flints; and its position was well defined, as it was nearly uniformly on the horizon of high-water level; and consequently, wherever the chalk met that horizon, the Forest-bed existed upon it, as at Cromer and Runton. Though not easy to ascertain its south-eastern boundary, as the chalk did not extend there, yet it might be presumed to be a mastodon-bearing bed at Easton Bavent, upon which the Forest-bed abutted, as it did upon the chalk, without overlying it. It was composed of a light blue clay remarkable for false stratifications and an indurated gravel, answering to the loess and valley-gravel, which marked another point of agreement with the river-valley formations. These component parts, especially the gravel, abound with the remains of several species of *Elephas* and *Cervus*, which were found not rolled but sharply broken, together with the bones of cetaceans of enormous size, and much drifted wood, facts which indicated that the Forest-bed was a fluviatile or estuarine deposit open to the sea, and that the Elephantine and Cervine remains had been carried into it by some powerful current. He regarded the German Ocean as the vast trough or river-bed, into which many tributary rivers poured their waters on the right and left banks, but closed by chalk hills to the south, so as to afford a communication between this country and the Continent, and a way for the mastodon, elephant, and other mammals to traverse. The soil of the Forest-bed, after being thus deposited, was raised to the surface, the forest grew upon it, a great change in fauna took place, different species of elephants and deer were introduced, and then, after remaining stationary for a long period, a gradual subsidence commenced and the laminated series began to be formed. After showing, from the researches of palæontologists, that with these laminated beds the temperature progressively lowered, the author enumerated these beds; namely, the freshwater beds, as at Mundesley and Runton; then the brackish beds, as the Pinna-bed at Mundesley; next, marine, and, among them, the Upper Norwich Crag, and the Chillesford sand and clays, as the land continued to subside, were deposited successively in deeper and deeper water, and with shells of an increasingly arctic character. In thus placing the Chillesford sand and clays above the Forest-bed, he had deviated from the opinion entertained by Mr. Prestwich and other geologists, and formerly by himself; but a close examination of the Chillesford clay at Chillesford had led him to affirm the identity of the clay deposited at other places which he mentioned. Reference was then made by the author to the finding by Dr. Woodward in the laminated series at Scratly, of a specimen of the *Voluta Lambertii*. The identity of these beds was further increased by other gentlemen finding the same shell in them.

Passing over Mr. Woodward's corroboration of the true position of the Forest-bed, the author referred to Sir C. Lyell's 'Principles,' wherein he remarked that the refrigeration of the climate, evidenced by shells of an arctic character in the Chillesford beds, was such as to render a change of climate and an oscillation of its level necessary for the introduction of the Forest-bed, which he was inclined to regard as interglacial. With all respect to Sir C. Lyell, the author said it appeared to him that if such were the case, there would be shells of an arctic character dicovered prior to the Forest-bed, whereas all the antecedents of the bed, especially the mammalian remains, evidenced a continuous progression from the warmer climature of the Mastodon-bearing bed to the more temperate climature of the Forest-bed. The Mastodon altogether disappeared in it, but the *Elephas* (*Loxodon*) *meridionalis* retained all the rugosity of its disks. The author next spoke of the mammaliferous bed of flints, containing remains of the *Mastodon arvernensis*, as having been regarded as part of the mammaliferous Crag, but he considered that it ought to be placed in the older Pliocene, while the upper parts of it should be assigned to the Pleistocene. No mention had been made by him of the Coralline and Red Crags, because he was inclined to regard them as members of an entirely distinct river-system. An examination of changes "of oscillation" of the levels might be carried into the older strata, so as to afford proofs of repeated subsidences and reelevations of the site of the present German Ocean, which would render the above statements quite common-place.

On some recent Discoveries of Fossils in the Cambrian Rocks. By HENRY HICKS, *M.R.C.S.E.*

In the "Report on the Menevian Group and the other Formations at St. David's" to the British Association in 1866, by Mr. Salter and the author, it was stated that no fossils had at that time been discovered by them during their researches in the neighbourhood, below the topmost purple beds of the Cambrian rocks, or rather in that series consisting of purple, red, and green sandstones, shales, and conglomerates, well known to belong to the "Harlech group" of Prof. Sedgwick, and "Upper Longmynds" of Sir R. Murchison.

In the summer of last year, however, the author was fortunate enough to find a small *Lingulella* in one of the red beds at the upper part of the series, and soon afterwards the same species in beds much lower, along with indications of other fossils. During the present summer, again, the author has been able to go still deeper, and to prove beyond doubt the presence in the series of a really rich fauna, comprising species belonging to no less than *ten* different *genera* (in addition to the tracts and burrows of Annelids), and consisting of Trilobites, Phyllopods, Brachiopods, and Pteropods. Therefore that portion of the Cambrian rocks known as the "Harlech group" or "Upper Longmynds," cannot henceforth (and as it has hitherto been) be classed with the so-called sterile bases of the fossiliferous rocks, but rather looked upon as a highly important group, which contained the imperishable monuments of almost the earliest states of life known. These discoveries also seem to lead the mind at once to anticipate the more than probable fact, that wherever sedimentary rocks occur, evidence of former life, in some shape, is likely to be present, and also to be disclosed ere long.

The section exhibited was taken across the line of strike of the Cambrian beds, on the coast to the south of St. David's, extending from the central mass of altered beds (syenite of the Survey map) to the base of the "Menevian group," and including over 1500 feet of nearly vertical strata, comprising in ascending order,

		feet.	
	1. Conglomerates	50	Lower Cambrian.
	2. Olive-green sandstones	250	
Fossiliferous series.	3. Red and purple sandstones.	850	
	4. Yellowish and greenish sandstones	300	
	5. Purple and red sandstones..	100	
	A few grey beds at the base of the "Menevian Group."		

Over 1200 feet of the section are now known to contain fossils, and to have belonged to a period when the *Crustacea*, *Brachiopoda*, and the *Annelida* were in existence; the lowest fossils found, next to the Annelid markings and tubes, being *Lingulella* and a small bivalved crustacean nearly allied to *Leperditia*. The valves of the latter are found as small ovate, convex plates. The author's friend Mr. Salter, to whom he sent some specimens, states that the "regular convexity and marginate outline show them to be nearly perfect valves. The oblique, parallel, but inosculating plication agrees with crustacean ornament, and no other; and the evidently thin shell (with no lines of growth) suggests a carapace of a crustacean, and not the shell of a Brachiopod, which is the only obvious alternative." These occur, along with *Lingulella ferruginea*, in some rather fine-grained red beds intervening between the olive-green grits, almost at the base of the section, and the purple sandstones above. They are also tolerably plentiful; but the colour of the rock is rather unfavourable to the exhibition of their minute characters. In the succeeding thick and compact beds of purple sandstones scarcely any traces of fossils have been found, nor indeed until about 50 feet of the yellowish sandstones of the overlying series have been passed. We then, however, meet with a bed exceedingly rich in fossils, equalling, indeed, in richness any of the beds of the "Menevian group;" but nearly the whole of those above and below seem almost altogether barren; and the author cannot help thinking that this strange barrenness in close proximity to a very rich colony, along with the fact that such colonies

are often separated by several hundred feet of barren strata, is one of the chief reasons why a Cambrian fauna has not been discovered before.

The fossils already discovered in this bed include a new genus, *Plutonia*, with species of *Paradoxides*, *Microdiscus*, *Conocoryphe*, *Agnostus*, *Theca*, *Discina*, *Obolella*, and *Lingulella*; the shells seem much like species in the "Menevian group," and are probably identical; but the Trilobites are all new species, and the new genus, for which the author proposes the name *Plutonia*, is only known to occur in these beds. This remarkable fossil is of very large size, equalling, indeed, in this respect *Paradoxides Davidis*. It is perhaps also more nearly allied to the genus *Paradoxides* than to any other known, but its peculiar character of being covered all over with very strong tubercles, associated with an unusual position for the eye suture, and straight, very long thoracic pleuræ, is sufficient to stamp it a new and distinct *genus*.

Resting upon the yellowish-grey rocks in which this richly fossiliferous bed occurs, is another series of purple and red sandstones, also slightly fossiliferous; and these directly underlie the grey beds of the "Menevian group," which contain *Paradoxides Aurora* and other fossils. Mr. Salter and the author have at different times proposed, in consequence of the lithological resemblance of the lower or *Paradoxides Aurora* beds of the "Menevian group" to some of the beds of the "Harlech group," to have the "Menevian" included in the Lower Cambrian. This now seems to the author more than ever necessary, and on palæontological grounds; for the genera, so far discovered, are either identical or very nearly allied; and some of the species are the same in both groups. On the other hand, there is very little connexion palæontologically between the "Menevian group" and the overlying "Ffestiniog group." No representatives of the more remarkable "Menevian" *genera* appear there; *Paradoxides*, *Microdiscus*, *Erinnys*, &c. are entirely absent, the very far-ranging genera *Agnostus* and *Conocoryphe* seeming alone of the Crustacea to reach upwards. Even with our present knowledge, therefore, of the two faunas "Harlech" and "Menevian," an unusually close connexion must be allowed to exist between them; and doubtless the more we know of the two, the more intimate will this yet seem, and the more shall we see the necessity of uniting both in the same geological division. To separate two such groups even into Upper and Lower Cambrian seems scarcely possible or reasonable; but to attempt to have a boundary for the great formations "Silurian" and "Cambrian" in the very heart of a period where such marked evidences of similarity in the life which ranged through them occur, would only prove once more the fallacy of artificial divisions instituted on *purely lithological* grounds instead of on evidence based on palæontological facts. If the "Menevian group" be included along with the "Harlech group" in the "Lower Cambrian" of Professor Sedgwick or "Cambrian" of Sir R. Murchison, we shall have a well-marked upper boundary to the formation defined by such genera as *Paradoxides*, *Microdiscus*, *Anopolenus*, *Erinnys*, and other allied forms; and as these are altogether so very distinct from any yet found in the higher groups, this limit is not at all likely to be disturbed by any future discoveries.

On the Ferruginous Sandstone of the Neighbourhood of Northampton. By CHARLES JECKS.

Having devoted some attention to the ferruginous sandstone of the Lower Oolite in the immediate neighbourhood of Northampton, the author suggested the following as the mode of its formation. Let the existence of a wide estuary be supposed, into which mighty rivers discharge themselves, depositing therein quantities of sand, mud, &c.; at times it may happen that one or more of the rivers above referred to may, perhaps, in periods of unusual outflow, bring down and deposit in the estuary a certain amount of iron; let then a subsidence be supposed, followed by the deposition of those shells inhabiting deeper water, and also accompanied by the formation of what is called ironstone. Then after a long period of time let there be a gradual upheaval, and as the submerged land approaches the surface, again an outpouring of iron, accompanied by the deposition of those shells inhabiting shallower water, drift-wood, &c.; and let this be continued for, it may be, many hundreds, perhaps thousands of years, together with fresh depositions of

mollusca, &c.; and, finally, let it be covered over by a deposit of sand, which would naturally be, in some measure at least, subjected to more or less denudation, and we have what seems to me an explanation of the formation of the ferruginous sandstone encircling the town of Northampton. Thus we have, in the first place, accompanying a great subsidence, the deposition of deep-water shells, and the conversion of the sand into *so-called* ironstone, often containing the casts of shells; then a certain amount of elevation, accompanied by the deposition of shells inhabiting shallower water; then sandstone with nodules of clay and ironstone and small pebbles, together with estuary shells*, ripple-marks, traces of serpulæ, and other marine annelides—of which latter, ripple-marks &c., there is a very fine specimen belonging to S. Sharp, Esq., in the Northampton Museum; and finally, layers of waved bands of sand at times apparently pure from any trace of iron, and evidently the result of shallow water.

On the Tertiary Deposits of Victoria. By H. M. Jenkins.

On the Noted Slate-veins of Festiniog. By S. Jenkins.

On the Oldest Beds of the Crags. By E. Ray Lankester.

In the county of Suffolk, lying on the London clay, wherever the Red Crag or the Coralline Crag is found, with few exceptions, is a bed from half a foot to three feet thick, of large and small nodules, bones, and teeth. All the nodules are rounded and waterworn, and so are the teeth and bones. They are evidently the members of an ancient stone beach, and form what the author calls the Suffolk Bone-bed. Most of the nodules are bits of rounded and worn clay, indurated with phosphate of lime, for which the bed is worked, and by a misnomer this deposit has been called the Coprolite-bed. The bits of clay which form the so-called coprolite are bits of London clay, just as in Cambridgeshire bits of gault and of oolitic clay are similarly phosphatized and worked as coprolite. Besides these nodules, the Suffolk bone-bed contains two distinct sorts of mammalian remains, those of terrestrial mammals (Mastodon, Rhinoceros, Tapirus, Ursus) and those of whales. In many of its features this bone-bed is similar to Mr. Gunn's stone-bed, containing, as it does, nodules and mammalian remains. The terrestrial mammals in both were washed, no doubt, from the same land-surface; but whence come all the great whales' remains and great sharks which are so abundant in this Suffolk deposit, and which are absent in Norfolk? The answer to this question is—they come from a great deposit of an earlier age, like that found in Belgium known as the Diestien or Black Crag; and in this we have evidence of a warmer sea, of a more Miocene-like fauna than in any of our well-preserved East-Anglian crags—either Coralline, Red, or Norwich. Most perfect remains of more than twenty long-snouted whales, such as now live in tropical seas, of huge sharks 80 feet long, and of a great seal with huge tusks, are found in the Diestien beds freshly and sharply preserved. In our Suffolk bone-bed these same bones and remains occur much washed and waterworn. They have been washed out of Diestien beds, and are proofs to us of the former existence of Diestien strata in Suffolk. But besides these remains, we find in the Suffolk bone-beds certain sandstone nodules which the author has lately found strong reason to believe are bits of the old Diestien deposits indurated and waterworn. This sandstone is even found *adhering* to the sharks' and whales' teeth and bones, but never to the mastodons'. But besides that, the specimens exhibited show a great number of shells preserved in that sandstone. These shells are not the shells of the Red Crag, nor even of the oralline Crag, for they occur among the waterworn nodules quite below either of these deposits. It is true that all the constituents of the Suffolk bone-bed are sometimes dispersed in small numbers through the Red Crag, but this is what we must expect in the deposit of so destructive a sea. The most important

* Since the above paper was read, I find that a species of shell, which I believed to be estuarine, is *not* so, and therefore the statement about estuary-shells must be somewhat modified. I believe, however, that these shells will still be found by a careful search after them.—C. J.

fact about these nodules is the abundance of a Black Crag or Diestien shell, *Isocardia lunulata.* The shell does not occur in either Red or Coralline Crag; but out of every forty nodules with fossils in them, you have seven specimens of *Isocardia.* Even *Isocardia cor* is most rare in our English Crags. Only half a dozen specimens have been found altogether in the Coralline and Red Crag. The presence of this shell in these nodules proves that the nodules are bits of a very different deposit, and probably of a Diestien age, not necessarily of *exact* equivalence with the Belgian Black Crag. We know how much a few miles of distance may affect a marine fauna; and it is most probable that the Suffolk deposits were always littoral or sublittoral, while those of Belgium accumulated in deep water. These nodules, which probably are of great importance, are supposed by some to be of indurated Coralline or Red Crag—by Mr. Searles Wood and, the author believed, by Sir C. Lyell; but a careful examination only is required to convince any one that such is not their mineral structure, and that the shells and bones they contain are those of Diestien age. The difference between the Diestien fauna and the Red and Norfolk Crag fauna is very great. Great changes as to glaciation have gone on between the two. The Coralline Crag bridges over the break in part, as does the yellow Antwerp Crag. The presence of derived Mastodon-remains in the Red and Norfolk Crag, and of Diestien *Cetacea* in the Red Crag too, is always most deceptive, and tends to mislead the judgment as to the true character of those beds.

On the Range and Distribution of the British Fossil Brachiopoda.* *By* J. Logan Lobley, *F.G.S.*

This paper was read in explanation of a series of Tables exhibited to the Section, and prepared with the view of showing, by a new arrangement, the range, distribution, increment, decrement, and maximum development of each subgenus, genus, and family, as well as of the class of Brachiopoda in British strata. The paper contained a summary of the results shown by the Tables, and was accompanied by lists of the species hitherto discovered in each formation, or minor group of rocks, in which the class is represented.

The first of the Tables gives the range and distribution of each genus, the genera being arranged in the order of their incoming or earliest appearance in British strata. The number of species of each genus in any geological formation is represented by short thick lines, each of which indicates the presence of one species. These lines are so arranged that the increment, decrement, and maximum development of each genus is distinctly shown, and the number of species of each genus in each formation in which it appears may be at once ascertained.

The second Table gives the genera arranged according to their family alliances, and shows the family to which each genus belongs, the order in which each family has appeared, and the number of species as well as of genera in every formation in which the family is found.

The third table is a summary of the second, in order to show more distinctly the increment and decrement of each family without reference to its genera, each line representing a species as in the other Tables.

The fourth Table is a summary of the third, to represent at a glance the relative importance of the representation of the class Brachiopoda in each geological formation.

The following are some of the more prominent results shown by these Tables. Of the forty-seven genera and subgenera, eleven are represented by species now living in the seas of our globe, and are therefore recent as well as fossil genera. Of these, *Discina, Lingula, Crania, Rhynchonella,* and *Terebratula* range from Palæozoic rocks. The genera *Leptæna, Spirifera,* and *Spiriferina* range from Palæozoic into Mesozoic, but do not reach Cainozoic strata, while each of the following twelve genera is characteristic of a single formation:—*Kutorgina* (Lingula flags), *Acrotreta* (Llandeilo), *Orthisina* (Caradoc), *Orbiculoidea* (Wenlock), *Nucleospira* (Wenlock), *Merista* (Middle Devonian), *Uncites* (Middle Devonian),

* Some of the details of this paper are given in the Geological Magazine for November, 1868, vol. v. p. 497.

Davidsonia (Middle Devonian), *Stringocephalus* (Middle Devonian), *Rensselæria* (Middle Devonian), *Terebrirostra* (Upper Greensand), *Magas* (Chalk). Thirty genera are essentially Palæozoic, and eight genera have not been found in any other than Mesozoic strata, though four of these have living representatives, while not one genus can be considered characteristic of Cainozoic strata.

Of the nine families in which the forty-seven genera and subgenera may be placed, one, *Productidæ*, is confined to Palæozoic strata, and one, *Thecididæ*, is characteristic of Mesozoic rocks. This family, however, although not represented in Cainozoic strata, has a species living in the present seas. *Strophomenidæ* and *Spiriferidæ* may almost be said to be Palæozoic, since very few species of either of these families have been found in rocks newer than the Permian, while in older strata the species of both are most numerous.

The families which range from the Palæozoic rocks to the present time, and are represented by recent species, are *Lingulidæ*, *Discinidæ*, *Craniadæ*, *Rhynchonellidæ*, and *Terebratulidæ*.

When we consider the range and distribution of the class as a whole, we find that it is represented in British strata by a very large number of species, some of which are found in almost every geological formation. Coming into existence, as far as we yet know, in Cambrian times, Brachiopoda abounded in Silurian seas; but the class attained its maximum development in the Carboniferous period. A small number of species have been taken from Permian rocks; but Triassic strata have not hitherto yielded us any. When we examine Liassic and Oolitic strata, we find again a large number of species, which, however, become fewer as we ascend the scale until we reach the Portland rocks, in which no Brachiopod has been found. The class again increases in importance in Cretaceous strata, and again diminishes in Tertiary formations, which have yielded hitherto not more than eight or nine species.

Although in British seas living Brachiopods are very rare, yet they are by no means so in the seas of southern latitudes, the bays and harbours of Australia swarming with *Waldheimia* and other forms of this interesting and remarkable class of the animal kingdom.

On the occurrence of Spherical Iron Nodules in the Lower Greensand. By JOHN LOWE, *M.D.*

Two years ago a large number of spherical pieces of sandstone was found in a railway-cutting at Walferton, near Lynn. They were mostly about the size of ordinary marbles, and were found to consist of a variable number of concentric laminæ resembling the ordinary "car"-stone of the district, and containing in their interior a quantity of loose grains of pure sand, with occasionally a small vitreous-looking fragment of organic matter.

The hill through which the cutting is made is about 50 feet in height at its highest point, and is composed of bands of yellow sand of variable degrees of hardness, but always of a friable nature. On the summit is a thin layer of iron or car-stone, which is largely used for building. There is no superincumbent chalk nearer than Sandringham, a distance of about a mile and a half.

On examining the sides of the cutting, the sand was found to be perforated by some boring animal (a large species of *Teredo*? or *Pholas*?). The borings have generally a horizontal direction, but sometimes pass upwards from one layer of sand into another. They are usually long and somewhat widely separate, never apparently crossing each other, as is seen in Pholas-borings. They are filled with sand of a much coarser quality than that which surrounds them, but when they take an upward direction the sand they contain is of a finer grain. The periphery of the borings is hardened by the deposition of iron, so as to form a tube. At the extremity of each there occurs one of the spherical bodies above described.

It is obvious that all the borings have been filled with sand, carried in and deposited by water, and that a stream of ferruginous water has subsequently percolated through the bed of sand, giving rise at the same time to the nodules and to the hardened periphery of the tubes.

It seems not improbable that the deposition of the iron has been determined by

the presence of organic matter. In the ordinary iron nodules, common in the district, wood or other organic matter is commonly present, and seems to have served as a nucleus of attraction for the iron. Even in the adjacent peat-beds logs of wood are found converted into solid crystalline iron pyrites. [Specimens of ironstone formed round the roots of couch-grass were exhibited; these were of recent formation on the surface of the ground.] Mr. Judd has found similar formations on the roots of willow in sand-pits in Lincolnshire. There is therefore ground for supposing that the remains of the boring animal in the end of the tubes gave rise to the spherical nodules, and that the hardened circumference of the borings was in the same manner due to the presence of traces of organic matter left in the process of boring.

On the Coal-field of Natal.
By Dr. Mann, *F.R.G.S. &c., Special Commissioner of the Government of Natal.*

The position and general configuration and geological character of the colony of Natal were described, and the presence of coal-deposits on the surface in various positions was explained. The history of the gradual discovery of the deposits was briefly sketched, and the quality and character of the coal was then considered. In the last and most important trial recently made to determine the question of quality, seven tons were used on board the surveying-ship 'Hydra,' and compared with equal quantities of Cardiff and West-Hartley coal. The result of this experiment was, that steam was up with Cardiff coal in 60 minutes, with 26 cwt. consumed; West-Hartley coal in 50 minutes, with 32 cwt. consumed; Natal coal in 55 minutes, with 30 cwt. consumed.

In steaming on the *third* grade, the consumption per hour was—

Cardiff coal	1553 lbs.
West-Hartley coal......	1648 ,,
Natal coal	1568 ,,

In steaming on the *third* grade, the consumption was respectively—

Cardiff coal	1624 lbs.
West-Hartley coal	2293 ,,
Natal coal	2128 ,,

The several samples yielded—

Cardiff......	9	per cent. of ashes,	2	per cent. of clinker.
West-Hartley	8	,, ,,	5	,, ,,
Natal	16	,, ,,	7	,, ,,

For easy steaming the Natal coal was deemed nearly equal in commercial value to Cardiff coal; but with full steam a larger quantity of Natal coal was required on account of the masking of the combustion with ash.

Specimens of the coal and of organic remains of *Glossopteris*, from the coal-deposit of Bushman's River, were exhibited, and the inference was drawn that in all probability the Natal coal will prove to be of the Jurassic or Cretaceous age.

On the Sequence of the Deposits in Norfolk and Suffolk superior to the Red Crag. By George Maw, *F.G.S., F.L.S., &c.*

In connexion with a large diagrammatic section from the neighbourhood of Aldborough in Suffolk to the Norfolk coast, and detailed sections of the strata at different localities, drawn to scale, reference was made to the various disputed points on the sequence of the more recent deposits of the eastern counties. Although the superposition of the Chillesford beds on the Norwich Crag had been questioned so recently as during the late session of the Geological Society of London, it was now, the author believed, admitted by every geologist acquainted with the district. It was suggested in general terms by Mr. Prestwich, eighteen years ago; and the recent labours of Mr. J. E. Taylor, in the Norwich district, in distinguishing and separating the upper from the Lower Norwich Crag, had fixed

an exact horizon by which the series in Norfolk and Suffolk could be correlated. Mr. Maw considered that the whole of the beds above the oblique ferruginous Red Crag in the well-known Chillesford Crag-pit pertained to the Chillesford Clay series. The Fluviomarine, or Lower Norwich Crag, was here wanting; but he disagreed with those who considered the obliquely bedded ferruginous Red Crag as the equivalent of the Norwich Crag; for in its occurrence at Thorpe, in Suffolk, within three and a half miles of Chillesford, it showed no approach in either its physical or palæontological features to the Red Crag. The Chillesford beds extend transgressively over the Coralline Red and Fluviomarine Crags, and do not appear to pass upwards in conformable succession from any of the subjacent beds. The upper part of the Chillesford beds probably graduate into the drift underlying the Boulder-clay of High Suffolk. These were considered older than the coast beds of Cromer, and appear to partake of the general denudation contour of the country, having been extensively denuded in the excavation of valleys that are cut deeply through them into the chalk and other older formations. The coast-beds, including the forest-bed of Cromer (with which the author identified the other forest-beds along the S.E. and S. coasts), the laminated beds, and the overlying Boulder-till and contorted drift, were considered more recent, being deposited after a long interval of denudation and disposed with reference to the existing coast outline. The resemblance in the fauna and flora of the Mundesley freshwater deposit to that of the forest and laminated beds was noticed, and the Mundesley peat and other thin layers of similar matter in the Norfolk coast-till, were considered to be merely a recurrence of the laminated beds at its base. The Thames valley deposits at Grays Thurrock might be contemporaneous with the Norfolk coast-beds, and they exhibit a contorted structure at their base. The phenomenon of "trail" or surface furrowing and rearrangement of drift, which had been described by the Rev. O. Fisher as the result of land-ice, did not appear to be accountable on any other theory. It seems to have been one of the most recent phenomena applied to the general denudation contour of the land-surface. It was not confined to the east of England; and the author exhibited a drawing of a section of stratified drift at the Bangor Station, North Wales, which had been rearranged in surface-furrows and pouches similarly to Mr. Fisher's "Trail" in the east of England. It was possible that it might have been contemporaneous with the deposition of the glacial beds on the Norfolk coast, which were also deposited subsequently to the land-surface receiving its present denudation contour.

On New Discoveries connected with Quaternary Deposits. *By* Charles Moore, *F.G.S.*

When examining an oolitic quarry at Falkland the author discovered in a fissure at about 40 feet from the surface, a drift with a number of small teeth and bones of mammals, and that subsequently he obtained them in great abundance, many of them belonging to small rodents. His attention being thus directed to the presence of mammalian remains in the fissures of the Oolite, he had since obtained them of many genera under similar circumstances along the escarpments of the Oolite through Somersetshire and Gloucestershire, associated with freshwater shells and bog-iron ore, which latter forms a considerable proportion of the material filling up the fissures. At Falkland twenty-two hut circles had been destroyed in quarrying the stone within a few years, and the author suggested it was probable the material filling the hut circles and the oolitic fissures was of the same age, though at the present time he had no distinct evidence to prove such to be the case.

On the Geology of the Chapada Diamantina in the province of Bahia, Brazil. *By the* Rev. C. G. Nicolay.

The information which we possess as to the geology of the province of Bahia is scanty, but, as far as it goes, satisfactory. The engineers Halfeldt, Vivian, and Cato have examined respectively the Rio di São Francisco, the route from the city of Bahia to Joazeiro on the same river, and to Sª Isabel de Paraguassu in the Chapada Diamantina; my own observations, besides those in that locality,

extend for about sixty miles round the city of Bahia, and on the new road to the Chapada by the Mato, or forest of Orobo.

The conclusions which may be arrived at from these and other sources are, generally, that—

1. There is a uniform strike and dip throughout the province within these limits, say, N.N.E. and S.S.W., with comparatively little variation.

2. The province may be geologically divided into zones.

(1) Conglomerate and schists near the coast.

(2) Sandstone in the Reconcavo from the city to the Lago of the river Paraguassu.

(3) Of primitive rock extending to the pastoral district of the Serra da Mangabeira.

(4) Of sandstone in that serra.

(5) Of primitive rock with nearly level surface (Taboleiros). This is some twenty leagues in breadth, and is the district of cataracts on the rivers. It is traversed by enormous masses of quartzose rock.

(6.) Of forests under which probably sandstones predominate.

(7) Of limestone.

(8) Of conglomerates forming the Chapada, so called from the horizontal line which the tops of the hills present to the eye. All these cross the province from the Rio Paraguassu to the Rio di São Francisco.

The Chapada is 200 miles from the west side of the Bay of All Saints, commonly known as Bahia, *i. e.* the bay which is again twenty-seven miles from the city of that name. It forms the eastern watershed of the Rio di São Francisco, and has within itself the sources of the rivers which fall into the sea within the circuit of the great river. Its height above the level of the sea may be approximately stated as 3000 feet. The diamond workings are carried to the top. The conglomerates of the Chapada differ from those of the coast principally in that the former are, and the latter are not, highly metamorphic; they have also greater development in the Chapada, as schistose formations, have on the coast; both contain diamonds, but those near the coast have been discovered but recently, and for local reasons the workings, though rich, have been abandoned.

The geological series at the Chapada is, descending—

1. Conglomerate;	3. Sandstone;	5. Schist;
2. Quartzite;	4. Limestone;	6. Primitive rock.

These are traversed by dykes and veins of trap and chert, and intervening between the harder rocks, veins of dirt are not uncommon, as also of sand and clay-slate. These afford facilities for the entrance of water between the strata, by which their rapid disruption is effected; and caverns, named Grunais, are often formed by the disintegration of the softer rocks beneath the conglomerate.

While at the Chapada (December 1865) the author ascertained that the quartzite is the matrix of those crystals of iron pyrites the presence of which marks the diamond cascalho or gravel, but saw no trace of diamonds in that rock; and since they abound in the Grunais, of which the conglomerate forms the roof, concluded that diamonds are formed in the softer veins and strata which separate the harder rocks. When diamonds are found, cascalho (a water-worn gravel) is present. The most marked constituents of this are:—

1. Crystals of pyrites.
2. Specula of magnetic iron.
3. Fejoes (schorl).
4. Fabras, } *i.e.* brown hydrophos-
5. Caboclesphate of alumina.
6. Pingua d'agoa (rolled hyaline quartz).
7. Pedra de ferro (oxide of iron).
8. Pedra de fogo (black silica).

The mineral equivalents are taken from M. Damon's analysis, from which it appears that the presence of Yttria characterizes the cascalho of the Chapada.

Diamonds are found of all colours, but the colour is mostly superficial. Green predominates, but each locality has its characteristic colour, quality, and crystallization, which are well known.

What may be called imperfect diamonds are also found; the most important of these is the "Carbonate," which is now commonly used in cutting diamonds.

The diamond-workings of the Chapada had, twenty years ago, the town of Santa Isabel as their centre; since then they have moved northward to Lencoes, now a city, and have extended more than thirty miles beyond it.

There seems no reason why the yield of diamonds should decrease so long as the present price is maintained; new localities, not only in the Chapada, but in other parts of the province, as at Pitanga, near Bahia, already noticed, will be found when required, and the province maintain its reputation of being the main source from which the market is supplied. The value of diamonds raised cannot be accurately determined, since only a small part comes to Europe through the regular channels, but it may probably exceed £500,000 in favourable seasons, *i. e.* when water is abundant.

On the Fossil Fishes of Cornwall. By C. W. Peach, *A.L.S.*

In 1841 the author read a paper at the Meeting at Plymouth on Cornish Fossils, in which he said that he had found, at "Punch's Crossquarry Fowey, portions of fish remains." At the Meeting at Cork in 1843 he exhibited finer and better specimens, some of them found by Mr. Couch at Polperro, and still considered them portions of fishes, and was supported in this opinion by the late Professor E. Forbes and others present there. Up to 1849 he did all possible to extend his researches, and on both sides of the county he was fortunate enough to get fish-remains. In December of that year he left Cornwall, and has not been there since. Fishes these things were considered until 1855, when Professor M'Coy, after a visit to Cornwall with Professor Sedgwick, stated, in 'The British Palæozoic Fossils,' published at Cambridge, "that he had carefully examined some of the specimens in the museums of Penzance and Truro, and many others that he had collected; and had sections prepared for the microscope, and had come to the conclusion that they were not *Fishes*, but *Sponges*, of which he made out two species." Up to April last they have been considered so, when Mr. E. Wyatt Edgell, in a letter in the Geological Magazine, asserted that the so-called *Steganodictyum*, or sponges, of M'Coy, were *true fishes*, belonging to *Pteraspis*, and since Professor Huxley, and Messrs. E. Ray Lankester, Salter, and Woodward have stated the same. Thus, then, although these fossils have been so long under a cloud, light has broken in upon them, and now their true history will be told by Messrs. Powrie and E. Ray Lankester in their beautiful monograph of these hitherto obscure Pteraspid forms. Since learning the change of opinion, he turned out the contents of a box packed in Cornwall in 1849, and, amongst a few pretty specimens of fish-remains, found a splendid but imperfect cephalic shield of Pteraspis, six inches in length; it is beautifully marked with delicate waved lines, and shows tubercles and cancellated structure. As it is so much larger than any figured in the monograph abovementioned, no doubt it will prove a new species. Although he has remained silent so long, his opinion has never changed as to the fish-nature of these remains; and in all his rambles over the rocks of the Old Red Sandstone in Scotland, with the exception of one small piece, tuberculated like the dermal plate of a Coccosteus, and also the cancellated structure in the decayed bones of Osteolepis, he has found none like the Cornish ones. The same network cancellated structure is to be seen in carboniferous fishes. This structure deceived Professor M'Coy and others, and hence their objection, because no similar appearance is known in the bone of any living animal.

On the Condition of some of the Bones found in Kent's Cavern, Torquay. By W. Pengelly, *F.R.S.*

In this communication the author confined himself to the marrow-bones which occur in the Cavern, and which present themselves in four different conditions—Entire, Crushed, Fractured, and Split.

The first, having but little information to give, he dismissed in a very few words.

The second were found at all levels, and invariably beneath huge blocks of limestone which had fallen from the roof; thus indicating that they were crushed

by the fall of the overlying block, that the place each occupied was the upper surface of the deposit when the block fell, that the deposit was capable of offering a firm resistance to a heavy falling mass, and that the Cave-earth was introduced into the Cavern successively and at many different times.

The third class consisted of bones broken with an oblique fracture, and precisely resembled the larger remnants left by Hyænas, as the author had found by a series of experiments which he had made at the Zoological Gardens, London.

The fourth class of bones were those which had been split longitudinally, with a fracture more or less clean. Having shown that they were not divided by the Carnivora, nor by exposure to the weather, the author proceeded to show experimentally that Man, with no other tools than such as he could readily have commanded in the Palæolithic age, was perfectly capable of splitting them; and gave it as his opinion that the object was to obtain long laths of bone, for making such bone tools as the Cave men are known to have used.

On the Conchoidal Fracture of Flint as seen on Flint-faced buildings in Norwich, Yarmouth, &c. By C. B. Rose, *F.G.S. &c.*

On the Crag at Aldeby. By C. B. Rose, *F.G.S. &c.*

In the summer of 1865 the author was shown some mammalian bones from a brick-yard at Aldeby, near Beccles, but on the Norfolk side of the Waveney. Their colour and character indicating the existence of a Crag deposit, the author took an early opportunity of examining the spot from whence the bones were taken, and there his suspicion was quickly confirmed. After repeated visits to the locality he was enabled to give the following section. Beneath the vegetable soil lies a bed of coarsish flint gravel, 4 to 6 feet in thickness, followed by sand and shingle 1 to 2 feet thick. Immediately beneath this lies an excellent brick-earth loam, varying in thickness from 3 to 7 feet; this loam encloses a few subangular flints, and no other erratic bodies. To the loam succeeds a fine ferruginous sand to the depth of 6 feet, enclosing an abundance of the usual Upper Crag shells, the majority of the bivalves with the valves disunited. At the depth of 3 feet in this sand occurs a bed of *Mya arenaria* of all ages, with their valves united, and in the position in which they lived and died. Two separated valves of *Mya truncata* were only met with. It was in the immediate vicinity of this *Mya*-bed that the fragments of an antler of a *Cervus* was found, and also the vertebra of a small cetacean.

Cyprina islandica was abundant, but, unlike the *Myæ*, the valves were invariably disunited.

At the depth of 6 feet below the *brick-earth* is found a bed of shells in which *Astartes* predominated, with both valves united, whereas in the upper bed the valves were almost invariably found separated. Here the presence of water put a stop to further digging. The author bored beneath the *Astarte*-bed 8 feet, in a somewhat loamy sand with traces of shells.

In determining to what member of the Crag formation the Aldeby bed belongs, the author compared it with the approximating Crag beds of Norfolk, in preference to those of Suffolk, and more particularly with the Brammerton Crag (see Richard C. Taylor's section, published in the Geol. Trans. for 1823), a section to be depended on.

Now comparing the *horizon* of the Brammerton pit with that of Aldeby, the author feels compelled to place the Crag of Aldeby and the upper beds at Brammerton in the same category, and consequently under the denomination of Norwich Crag.

Fifty-six of the usual mollusks of the mammaliferous Crag are met with at Aldeby, viz. 40 bivalves, and 16 univalves. Also spines of *Spatangus purpureus*, and spines of an Echinus. Vertebra of a Delphinus, Otolites, and teeth of small fishes. Teeth of a small Rodent.

On the Thickness of the Chalk in Norfolk. By C. B. Rose, *F.G.S. &c.*

On a New Pterygotus, *from the Lower Old Red Sandstone.* *By* J. W. Salter, *A.L.S., F.G.S., &c.*

The new species was obtained from the lowest Old Red, or Ledbury Shales formation. It is a very large one, and must have measured 7 feet in length when perfect. Its head very square; the base of the swimming-foot small in proportion to that of other species. The chelate antennæ have the apices very greatly hooked, and the teeth close. Only fragments of the body-rings have been found. The tail-joint appears to have been oval. The specimens were found at Ewyas Harold, and are in the cabinet of Dr. M'Cullough.

On the Relations between Extinct and Living Reptiles, and on the present state of our knowledge of Pterodactyle. *By* H. G. Seeley.

On the Classification of the Secondary Strata of England. *By* H. G. Seeley.

On a Remarkable Incrustation in Northamptonshire. *By* Samuel Sharp, *F.S.A., F.G.S.*

In the section of a gravel-pit near Wold, about 14 miles N.N.E. of Northampton, had been exposed a mass of incrustation of carbonate of lime, the nucleus of which consisted of the water-plant *Chara vulgaris.* This mass was 10 feet in horizontal diameter as exposed in the section, and reached inwards about 4 feet from the plane of that section, as first seen by the writer. Its thickness was about 2 feet to 2 feet 6 inches. Above the mass of incrustation was a layer of a kind of calcareous paste, of a thickness of from 6 to 10 inches; and below it a similar layer of from 3 to 6 inches. This paste consisted entirely of the crushed material of the incrustation, of which it contained many fragments. At the bottom was a mixture of gravel and soil, of the thickness of about 9 inches.

The gravel in the pit is stratified. The strata ran up to the mass of incrustation on either side, sharply abutting upon it; and lower strata ran quite underneath, showing that there had been no partial subsidence or disturbance below.

It was evident that there had been formerly a pool of water at this place—about 10 feet across, and about 5 feet deep; the form of which, as shown by excavation, was basin-shaped, rounded at bottom, and spreading somewhat at top.

The writer concluded from these facts that this pool had been artificially formed; that the water had been highly charged with carbonate of lime; that, when the *Chara* came to grow in it, it became incrusted; that, by the process of the alternate or continuous growth and incrustation of the plant, the pool ultimately had been choked up, and becoming a mere quagmire, had finally been filled in with soil. The mixed gravel and soil at the bottom he thought had been the bottom of the pool; and the lower calcareous paste produced by pressure of the superincumbent weight, and the upper by the trampling of cattle in drinking.

The pit is situated on the slope of a valley; the gravel is very open, and overlies the porous beds of the ferruginous Northamptonshire sands; these repose upon the Upper Lias. No water had ever been known to, nor under existing conditions could possibly, stand in this gravel-pit.

The writer, therefore, contended—as great alterations in the local conditions had taken place since the time when this pool was formed and water accumulated in it to such a depth as to allow the *Chara* growing luxuriantly to within a foot of the surface; as those alterations probably involved an elevation of the district and the excavation in whole or in part of the present valley; and as the formation of the pool could only reasonably be accounted for by attributing it to human agency—that we had here anot er item of evidence of the high antiquity of the human race.

The Norwich Crags and their relation to the Mammaliferous Bed. *By* J. E. Taylor.

On the recent Discovery of Diamonds in the Cape Colony. By Professor TENNANT, *F.G.S.*

This gem, the author stated, had been found somewhat abundantly recently in the above district; and he exhibited the casts of some weighing nine carats, worth 500*l.* Some agate, chalcedony, and other precious stones found in the same deposit had been sent him, but he would have preferred some of the sand and mud in which they were deposited. One diamond, found very recently, weighed as much as fifteen and a half carats. The author was of opinion that before long we should have a large collection of diamonds from the above country, adding that, although we had heard a great deal of diamonds being found in Australia, those stones were not worth now so many pence as pounds had been asked for them.

Notes on certain Reptilian Remains found in the Carboniferous Strata of Lanarkshire. By JAMES THOMSON (*Glasgow*).

The attention that has been given recently to the Reptiles of the coal-period, makes the discovery of new forms or more perfect specimens of the utmost importance, as it will tend to throw light on species established hitherto on imperfect materials, more especially since the description of *Anthracosaurus Russelli* by Prof. Huxley in the Quarterly Journal of the Geological Society, vol. xix. p. 56.

The specimens which the author exhibited to the Section were found a few days before the meeting at Quarter, parish of Hamilton, Lanarkshire. They occur in the parting between a bed of ironstone-shale and coal. The ironstone varies in thickness from 1 to 14 inches, and overlies the coal, which is from 5 to 15 inches thick. The specimens are found lying on the surface of the coal, and invested by the superincumbent ironstone.

The whole of the remains retain their original structure, some specimens having their original form, while in others this has been somewhat affected by the pressure of the superimposed beds. The largest and most important specimen is the greater part of a skull of *Anthracosaurus*, measuring 10 inches long by 8 inches wide posteriorly; opposite the vomerine tusks it is 4 inches wide. The under side is turned upwards, exposing the stumps of forty broken teeth around its contour.

On the same slab, and partly resting on the posterior portion of the skull, there is an under jaw, with the anterior face thrown backwards, and which probably belongs to the same reptile. Also another upper jaw, which was found in the same locality, measuring $12\frac{1}{2}$ inches long by 4 inches wide at the widest part, with 7 perfect teeth, and the stumps of 18 exposed; a slab of ironstone with three ribs, and a vertebra greatly flattened, showing the neural canal &c.; while on detached pieces of coal are numerous bones and scutes. Also the anterior portion of two jaws of the so-called *Rhizodus lanceiformis* (?); the one is $9\frac{1}{2}$ inches long by 2 inches wide, with 8 perfect teeth, and the stumps of 7 exposed; the other is $7\frac{3}{4}$ inches long by 2 inches wide, and exposing 9 teeth, 5 of which are perfect, while the other 4 are partially broken. There is another reptilian jaw, the specific name of which the author was not acquainted with.

In the same parting there occurs, in remarkable abundance, specimens of the *Gyracanthus*, both lateral and dorsal spines, bones, and scales of various forms of fishes; such as *Megalichthys, Strepsodus, Pleurodus, Ctenacanthus major, C. minor, Pleuracanthus, Gyracanthus, Ctenodus,* and preserved in the same condition as those of the Reptiles.

Of *Rhizodus lanceiformis* (?) the author had discovered remains at Braehead, Renfrewshire; the beds in which they are found are at the base of our Scottish coal-measures in this part of Scotland, thus showing that this form had existed during the long period of time necessary for the deposition of upwards of 600 fathoms of strata.

The bed of ironstone referred to is of limited extent, and belongs to the upper members of the Scottish coal-measures; and at Quarter is 40 fathoms below the surface, and is the equivalent of the better known Airdrie black-band ironstone. It is a small basin, and situated on the south side of the River Avon, on the banks of which the ironstone crops out, while at its southern extremity it is thrown to

the surface by a trap-dyke, which trends from N.N.W. to S.S.E., displacing the strata about 90 fathoms.

On some New Fossils from the Longmynd Rocks of Sweden. By Prof. Otto Torrell.

The author exhibited a series of slabs marked by the impressions of various land-plants known to geologists by the name of *chondrites*. He had these fossil plants from a formation much older than any from which fossils have hitherto been obtained. The rocks from which they were derived were of an age similar to those of the Longmynd rocks in Wales. The under sides of many of the slabs were pitted with the markings of rain-drops; and the conclusion which the author came to was, that the character of the plants and the meteorological markings upon them indicated that they had been deposited under shallow-water conditions. This he corroborated by showing that a bed of shingle or conglomerate was associated with them, which he judged to have been part of an old sea-beach. The same slabs were marked by the trails of marine worms that had crawled over them. The casts of some of these worms were distinctly to be seen on the surface of the slabs. The slabs were handed round, and scrutinized most minutely by many geologists present.

On the Glacial and Postglacial Structure of Norfolk and Suffolk. By Searles V. Wood, Jun., *and* F. W. Harmer.

This paper was a summary of the results arrived at by the authors from a survey and mapping of the Crag and Glacial beds of Norfolk and Suffolk, upon the Ordnance (one inch to the mile) map, which they have been carrying on during the last four years. The paper was illustrated with a large map, constructed from their survey map, and copious detailed sections, traversing the counties in various directions, without which the paper itself is difficult to be understood. The principal results at which the authors have arrived at are as follows:—

That the Fluviomarine Crag of Thorpe and Bramerton, and of Wangford, Bulchamp, and Thorpe, near Aldborough, is coeval with the newer part of the Red Crag.

That the Crag of Burgh, Horstead, and Coltishall, in the Bure Valley, is a fluviomarine development of the Chillesford shell-bed, or Crag of Easton and Aldeby, which, divided from the Red and Fluviomarine Crag by an interval of sand of varying thickness, overlies the Red Crag at Chillesford, and the Fluviomarine Crag (or old Norwich Crag) at Thorpe and Bramerton.

That the so-called Crag of Belaugh, in the Bure Valley, and the so-called Crag of the Weybourne and Cromer coast, are newer than the Chillesford beds (which, unless the pebble-beds next mentioned be a still higher part of the Crag series, form the uppermost of the true Crag series), being characterized by the presence in profusion of a shell unknown to any bed of the true Crag series from the Chillesford clay downwards, viz. the *Tellina solidula*; and were introduced after an elevation of the Crag area had converted the southern portion of it into land, and given rise over the northern portion to extensive sands with pebble-beds, which rest on and indent the Chillesford clay in that northern portion. These sands with pebbles occupy in the south of Norfolk and north of Suffolk the same place relatively to the Contorted Drift as is occupied on the Cromer coast by the Weybourne sand (or so-called "Crag" of the Cromer coast), the Cromer Till, and the indenting sand (or bed C after-mentioned). These pebble-beds may thus represent in time either the whole or any one of the formations A, B, and C (described further on); or they may form merely the closing bed of the true Crag series*, in which case the Weybourne sand, the Cromer Till, and bed C are entirely unrepresented in the south of Norfolk and north of Suffolk.

That the forest beds of the coast, extending from Eccles to Weybourne, with their associated sandy clays of freshwater origin (being the oldest beds exposed along that coast, and having been partially destroyed by the denudation of the sea

* The authors are inclined to think that the second of these alternatives is the true one; and they hope to clear up the point by means of a fossiliferous pebble-bed near Bungay.

depositing the so-called Crag containing *Tellina solidula*), represent a land surface of some period anterior to this so-called Crag. That as this period extends from the close of the true Crag series downwards, such land surface may be either contemporaneous with the true Crag series (which has no place on the northern coast of Norfolk), or may be of a period intervening between the close of that series and the actual submergence of northern Norfolk, which was accompanied by the introduction of *Tellina solidula*, and the accumulation of the Weybourne sand, or so-called "Crag" of the Cromer coast *.

That the mammalian teeth and jaw fragments of *terrestrial* Mammalia (generally more or less rolled), obtained as yet from the Fluviomarine Crag and Chillesford beds, do not represent the mammalian fauna of the deposit in which they occur, but are derivative from some older bed.

That, contrary to the views of the Rev. John Gunn and others, who discover an Upper and Lower Boulder-clay in the cliffs between Weybourne and Eccles, and identify the former with the great Boulder-clay formation of the East of England, the authors regard everything in those cliffs as inferior, not only to the great Boulder-clay, but also to the extensive sands and gravels termed by them Middle Glacial; these sands and gravels (which underlie a large part of the great Boulder-clay in the counties of Norfolk, Suffolk, Essex, Hertford, Buckingham, and Leicester) only capping with their base the cliffs in places, but in greater mass forming the sand hills, which immediately inland occupy higher ground than the top of the cliffs, and are spread extensively over northern Norfolk.

That all the beds of the cliff-section between Eccles and Weybourne (except the patches of the base of the Middle Glacial sands, which in places cap it) form a series of themselves which they term the Lower Glacial, and are throughout characterized by the presence of *Tellina solidula*. These are divisible into the following, which are given in the *ascending* order.

A. The Weybourne Sand, the base of which, when resting on the Chalk, is often occupied by an accumulation of shell-patches known to collectors as "The Norwich Crag" of the coast. This sand becomes, east of Cromer, charged with lignite, and often laminated with bands of lignitiferous clay, in which condition it constitutes the "laminated series" of the Rev. John Gunn. In that condition it is unfossiliferous, the lignite intermixture apparently rendering it unsuited for molluscan life, of which the remains are usually present when in its pure condition. This sand passes up by interbedding into—

B. The Cromer Till, or "Lower Boulder-clay" of Mr. Gunn, a sandy clay with numerous small stones, and with occasionally a boulder of larger dimensions.

C. Sands which, where the cliff is uncontorted, are seen to be indented into a deeply eroded surface of the Till, and to have themselves been also denuded, so as to form an even floor for the ensuing formation, viz.:—

D. The Contorted Drift. This bed is the widest spread of the Lower Glacial series. It begins in the north of Suffolk as a reddish-brown brick-earth, a few feet thick, resting on the sands with pebbles, before described, but sometimes the pebbly sands have been removed. It comes up at the base of Pakefield and Corton cliffs (where, as well as in the sections at Bishops Bridge, Norwich, it is called by Mr. Gunn and others "Lower Boulder-clay"), and thickening rapidly as it extends northwards, comes out at the eastern termination of the Cromer coast section at Eccles, as the well-known Contorted Drift of that coast, from whence it extends continuously, and as the uppermost bed of the cliff (except the sand cappings) to Weybourne. The authors state that they have traced it from its attenuated commencement in the north-east of Suffolk and south-east of Norfolk in every direction northwards, and found it at Cargate Green, near Acle (ten miles only south of

* The authors would observe that the position of the bed yielding wood and mammalian remains beneath the Middle Glacial sands at Kessingland Cliff in Suffolk, seems, from its position relatively to the Chillesford clay, two miles distant, to be clearly subsequent to the close of the Crag series; but whether this bed be synchronous with the whole of the Forest and freshwater deposits of the Cromer coast, or whether the latter may not represent a much longer duration of land surface—a duration embracing the period of the Kessingland bed, but reaching back into the Crag period—must be determined by the palæontological evidence only.

the Cromer coast), overlain by the great Boulder-clay (or Upper Glacial), and at West Somerton (seven miles south-east of the Eccles termination of the coast section) overlain by Middle Glacial sand, and that again by the great Boulder-clay in direct superposition. In its brick-earth condition it is sometimes full of small stones, occasionally also of minute chalk fragments, and often contains large sand-galls. In the direction of Weybourne this deposit becomes more marly by the intermixture of fine chalk sediment; and west of Mundesley, at which place it begins to be contorted, great masses of pure white marl or reconstructed Chalk (which have been described as chalk-masses by observers) occur in it, which, by the weight of the bergs carrying them, have sunk in some cases into the subjacent Till, and even into the Weybourne sand. These marl-masses the authors describe as being detached fragments from the more inland portion of the Contorted Drift itself; which, inland from the coast, both southwards towards Reepham and Holt, and westwards towards Wells, becomes formed exclusively of this marl. They attribute the formation of this marly portion of the Contorted Drift to a discharge of ground-up Chalk from the *débouchure* of a glacier that occupied the Chalk country of Cambridgeshire and West Suffolk; the brick-earth which forms the easterly development of the Contorted Drift being due to a river discharge in that part, the two sediments intermingling in the intermediate area, and producing the alternations of marl and brick-earth there presented by this formation. The detached masses of the marl were, they consider, introduced into the brick-earth portion of the deposit by the agency of bergs, which, breaking from the glacier and grounding, picked up masses of the marl forming over the sea-bottom in that part of the area. These masses the bergs carried out into the area where the brick-earth was accumulating, and grounding again, imbedded them in the brick-earth, and even in the subjacent Till and Weybourne sand, contorting the beds in the process. From detached portions of this marl, which they have found as far south as Claydon, near Ipswich, and Stanstead, near Lavenham, in Suffolk, they infer that this deposit covered the west of Suffolk and Norfolk, but underwent great denudation in the former part by the waters of the Middle Glacial seas, the sands of that sea, west and south of Diss, lying up to bosses of it in some parts, and overlying it in others.

That the fauna of the Lower Glacial beds is marked by the disappearance of all except the boreal and arctic mollusca of the Crag, rather than by the introduction of a new fauna, the principal introduction being the *Tellina solidula*. A list of twenty-eight species of mollusca was given by the authors from these Lower Glacial beds.

That the sands and gravels, attaining frequently a thickness of fifty or sixty feet, which underlie much of the great Boulder-clay in the six counties before mentioned, and which, termed by the authors the Middle Glacial, pass over the Lower Glacial series, A, B, C, and D, just described, contain a molluscan fauna, of which they enumerate twenty-three species. The interest attaching to this fauna consists in the fact that *Pectunculus glycimeris*, which dies out in the newer part of the Red Crag, and is excessively rare in the Fluviomarine or true Norwich Crag, returned during this formation in abundance, as well as *Ostrea edulis*, a shell which similarly disappears in the newer beds of the Crag, and it is not known now within the Arctic circle. Although a bed, a few feet thick, of Boulder-clay identical in composition with the great Boulder-clay, but of very limited extent, occurs at the base of this formation at two places in north-east Suffolk, and at one place in Hertfordshire, its features and fauna both appear to indicate that some considerable amelioration of the very severe climate to which the marl of the Contorted Drift that preceded it was due, occurred in the interval occupied by this formation.

That the true widespread Boulder-clay of the east of England, termed by the authors the Upper Glacial, ceases from denudation in northern Norfolk, along a line drawn from Winterton on the north-east coast to Norwich, and thence passing near Aylsham through Cawston, Guestwick, and Barney, to a point a little north of Fakenham. On the east of the county (that is to say, to the south-east of a line joining Norwich and Happisburgh) the Middle Glacial sand and the underlying Contorted Drift crop out from beneath the true Boulder-clay in regular sequence; but over the centre of Norfolk the authors describe a very anomalous

structure, which is that the true Boulder-clay (or Upper Glacial) has been deposited in a great trough more than twenty miles wide, which has been excavated through the Middle Glacial sands and subjacent Lower Glacial beds down to the Chalk. The effect of this has been to bring the true Boulder-clay (or Upper Glacial), resting on the Chalk, down to a level on the west and south-west of Norwich, which in some parts is below that of the Crag, and nearly 100 feet below the position which it occupies when resting on the older Glacial beds in undisturbed sequence of deposit, the Chalk upon which the Upper Glacial thus rests direct being generally in a glaciated or disturbed condition.

That over the central part of Norfolk, where the Upper Glacial thus goes down in solid mass to the Chalk, it is overspread by extensive beds of Postglacial gravel*, which not only cap the plateaux, but spread over the sides of the valleys, sometimes forming a continuous wrapping sheet down to their bottoms, and presenting a general absence of terrace structure. These features the authors consider as repugnant to any theory accounting for the excavation of the valleys by river-action. Similar old Postglacial gravels are also present, but less extensively, in eastern Norfolk, where they rest on the denuded surfaces of the Upper and Middle Glacial formations; large sheets of them capping the former at Poringland, and the latter at Mousehold Heath.

That, in addition to these older gravels, sheets of a newer gravel, more or less concealed by the alluvium, occupy the bottoms of most of the river-valleys. This newer gravel they consider may be the deposits of rivers during the Postglacial period, and after the valleys had been formed by tidal action.

The sequence of the beds, omitting the Postglacial, may be summed up as follows, the beds being taken in descending order:—

1. The Upper Glacial, or true Boulder-clay of the East of England.
2. The Middle Glacial sands and gravels.
3. The Contorted Drift, beginning as a thin bed in the north-east of Suffolk, and thickening out towards the Norfolk coast.

$\}$ Part of the Glacial Series.

4. The Pebbly sands and Pebble-beds.
5. The Chillesford Clay.
6. Sands containing the Chillesford *shell-bed*, or *Crag* of Chillesford, Sudbourn Church Walks, Easton Cliff, and Aldeby, and Upper bed of Bramerton.
7. The Red and Fluviomarine Crag.

$\}$ True Upper Crag Series.

The Weybourn sand (A), the Cromer Till (B), and the indenting sand (C) (which with the Contorted Drift make up the Lower Glacial formation) come in below the bed No. 3, which spreads over them and over No. 4; but as they are absent where No. 4 is present, they, as before explained, may either represent No. 4, or No. 4 may be only the uppermost member of the true Crag series.

In South-east Suffolk No. 2 rests on 5, 6, or 7, but most frequently on No. 7, Nos. 5 and 6 having been much denuded prior to the deposit of No. 2.

BIOLOGY.

Address by the Rev. M. J. Berkeley, *M.A., F.L.S., President of the Section.*

After alluding to personal matters that had hitherto prevented him from carrying out his original intention of instituting a course of experiments illustrative of the theories which have lately been broached by Dr. Hallier and others respecting the origin of cholera and some other formidable diseases, the President proceeded as follows:—

Few points are of greater significance than those which touch upon the intimate

* In the small map of the Glacial beds of the east of England, printed by one of the authors for private circulation in 1865, the centre of Norfolk, where these Postglacial sands and gravels so extensively occur, was represented as principally occupied by the sands and gravels of the Middle Glacial series. This error, which the prosecution of their work has detected, the authors desire to call to notice.

connexion of animal and vegetable life. Fresh matter is constantly turning up, most clearly indicating that there are organisms in the vegetable kingdom which cannot be distinguished from animals. The curious observations which showed that the protoplasm of the spores of *Botrytis infestans* (the Potatoe mould) is at times differentiated, and ultimately resolved into active flagelliferous zoospores, quite undistinguishable from certain Infusoria, have met their parallel in a memoir lately published by MM. Famintzin and Boranetzky respecting a similar differentiation in the gonidia of Lichens belonging to the genera *Physcia* and *Cladonia*. It is, however, only certain of the gonidia which are so circumstanced; the contents of others simply divide into motionless globules.

A still more curious fact, if true, is described by De Bary, after Cienkowsky, in the division of Fungi known under the name of Myxogastres or false puffballs. Their spores, when germinating, in certain cases give rise to a body not distinguishable from *Amœba*, though in others the more ordinary mode of germination prevails. In the first instance De Bary pronounced these productions to belong to the animal kingdom, so striking was the resemblance; but in our judgment he exercised a wise discretion in comprising them amongst vegetables in a late volume of Hofmeister's 'Handbuch.'

The point, however, to which I wish to draw your attention, and one of great interest if ultimately confirmed, is that the gelatinous mass produced either independently, or by the blending of these Amœboid bodies, is increased, after the manner of true Amœbæ, by deriving nourishment from different organisms involved by accident from the extension of the pseudopodia. These strange bodies, according to our author, behave themselves precisely after the same manner as those enclosed accidentally in undoubted animals. If this be true, it shows a still more intimate connexion, or even identity of animals and vegetables than any other fact with which I am acquainted.

You are all doubtless aware of the important part which minute fungi bear in the process of fermentation. A very curious contribution to our information on cognate matters has lately been published by Van Tieghem, in which he shows that tannin is converted into gallic acid by the agency of the mycelium of a species of *Aspergillus*, to which he has given the name of *Aspergillus niger*. The paper will be found in a late Number of the 'Annales des Sciences Naturalles,' and is well worth reading.

We now come to the subject which I mentioned at the beginning of this address, viz. the theory of Hallier respecting the origin of certain diseases. His observations were at first confined to Asiatic cholera, but he has since made a communication to the authorities of the Medical Department of the Privy Council Office, to the effect that in six other diseases—typhus, typhoid, and measles (in the blood), variola, variola ovina, and vaccinia (in the exanthemes)—he has found certain minute particles which he calls micrococci, which under culture-experiments give, for each of the above-mentioned diseases, a constant and characteristic fungus. He states that in variola he gets the hitherto unknown pycnidia of *Eurotium herbariorum*; in vaccinia, *Aspergillus glaucus*, Lk.; in measles, the true *Mucor mucedo*, of Fresenius; in typhus, *Rhizopus nigricans*, Ehrenberg; and in typhoid, *Penicillium crustaceum*, Fries. He adds that the culture-experiments, especially with the variola diseases, have been so very numerous as to exclude from the results all supposition of accident—that different districts, different epidemics, and different times have given identical results. I am anxious to say a few words about the subject, because most of the reports which have been published in our medical journals give too much weight, in my opinion, to his observations, as though the matter had been brought to a logical conclusion, which is far from being the case. I am happy to say that it has been taken up by De Bary, who is so well calculated to give something like a conclusive answer to the question, and also that it has been taken in hand by the medical authorities of our army, who are about to send out two of their most promising young officers, perfectly unprejudiced, who will be in close communication both with De Bary and Hallier, so as to make themselves perfect masters of their views, and to investigate afterwards the subject for themselves.

The fault, as I conceive, of Hallier's treatise is, that while his mode of investi-

gation is unsatisfactory, he jumps far too rapidly to his conclusions. It is quite possible that certain fungi may occur constantly in substances of a certain chemical or molecular constitution, but this may be merely a case of effect instead of cause. Besides, as I conceive, the only safe way of ascertaining what really originates from such bodies as those which he terms micrococci, or the larger ones commonly called yeast-globules, is to isolate one or two in a closed cell so constructed that a pellicle of air, if I may so term it, surrounds the globule of fluid containing the bodies in question, into which they may send out their proper fruit—a method which was successful in the case of yeast, which consists of more than one fungus, and of the little *Sclerotium*, like grains of gunpowder, which is so common on onions. Any one who follows the growth of moulds on moist substances, and at differents depths, as paste of wheat or rice-flour, will see that numberless different modifications are assumed in different parts of the matrix, without, however, a perfect identification with fungi of other genera. Some of these will be seen in the figures I have given in the 'Intellectual Observer,' and the 'Journal of the Linnean Society,' of different forms assumed by the moulds to which that formidable disease, the fungus foot of India, owes its origin. This is quite a different order of facts, from the several conditions assumed by the conidiiferous state of some of the vesiculiferous moulds—as for example *Botrytis Jonesii*, which has been ascertained to be a conidiiferous state of *Mucor mucedo*, while two forms of fruit occur of the same mould in what is called *Ascophora elegans*; or the still more marvellous modification which some of the Mucors undergo when grown under water, as evinced by some of the Saprolegniæ, the connexion of which was indicated by Carus some fifty years ago, but which has never been fully investigated.

When Hallier intimates that he has raised from cholera evacuations such a parasite as *Urocystis occulta*, he should have been content with stating that a form of fructification occurred resembling, but not idenical with, that fungus. Indeed, a comparison with authentic specimens of that species, published by Rabenhorst, under the generic name of *Ustilago*, shows that it is something very different, and yet the notion of cholera being derived from some parasite on the rice-plant rests very much on the occurrence of this form. But even supposing that some Urocystis (or *Polycystis* as the genus is more commonly named) was produced from cholera evacuations, there is not a particle of evidence to connect this with the rice-plant. In the enormous collections transmitted by Dr. Curtis from the southern United States, amounting to 7000 specimens, there is not a single specimen of rice with any endophytic fungus, and it is the same with collections from the East. Mr. Thwaites has made very diligent search, and employed others in collecting any fungi which may occur on rice, and has found nothing more than a small superficial fungus nearly allied to *Cladosporium herbarum*, sullying the glumes exactly as that cosmopolitan mould stains our cereals in damp weather. Rice is occasionally ergoted, but I can find no other trace of fungi on the grains. Again, when he talks of *Tilletia*, or the Wheat Bunt, being derived from the East—supposing wheat to be a plant of Eastern origin, there is no evidence to bear out the assertion, as it occurs on various European grasses; and there is a distinct species which preys on wheat in North Carolina, which is totally unknown in the Old World.

I might enter further into the matter, were it advisable to do so at the present moment. All I wish, however, is to give a caution against admitting his facts too implicitly, especially as somewhat similiar views respecting disease have lately reached us from America, and have become familiar from gaining admittance into a journal of such wide circulation as 'All the Year Round,' where Hallier's views are noticed as if his deductions were perfectly logical.

The functions of spiral vessels, or of vascular tissue in general, have long been a subject of much controversy, and few matters are of more consequence as regards the real history of the distributicn of sap in plants. A very able paper on the subject, to which allusion was made by Dr. Hooker in his address, has been published by Mr. Herbert Spencer (than who few enter more profoundly into questions of physiology) in the Transactions of the Linnean Society. By a line of close argument and observation he shows, from experiments with coloured fluids capable of entering the tissues without impairing vitality, and that not only in

cuttings of plants, but in individuals in which the roots were uninjured, that the sap not only ascends by the vascular tissue, but that the same tissue acts in its turn as an absorbent, returning and distributing the sap which has been modified in the leaves. That this tissue acts some important part is clear from the constancy with which it is produced at a very early stage in adventitious buds, establishing a connexion between the tissues of the old and new parts. This appears also from the manner in which in true parasites a connexion is established between the vascular tissue of the matrix and its parasite, as shown by our President in his masterly treatise on Balanophoræ, and more recently by Solms-Laubach in an elaborate memoir in Pringsheim's Journal. It is curious that in organs so closely analogous to the tracheæ of insects a similar connexion should long since have been pointed out by Mr. Newport, in the case of certain insect parasites.

A circumstance, again, which constantly occurs in the diseases of plants confirms the views of Mr. Herbert Spencer. In diseased turnips, grapes, potatoes, &c., it is especially the vascular tissue which is first gorged with the ulmates which are so characteristic of disease.

Monsieur Casimir De Candolle, in a clever memoir on the morphology of leaves, has come to the conclusion, after studying the arrangement of their vascular tissue, that they are branches in which the side towards the axis, which he calls the posterior, is atrophied. This subject has been followed out in those organs which are considered as modifications of leaves, as, for example, stamens, in which he finds sometimes the posterior side, sometimes the anterior, atrophied. If his theory is true, this would result from the way in which they originated, and the reference they bore to contiguous organs. The subject is well worth attention, and may eventually throw considerable light on those anomalous cases in teratology which will not accommodate themselves to the usual theory of metamorphosis. Some of these cases are so puzzling and complicated, that a very clever botanist once told me, "Monstrous flowers teach us nothing,"—not meaning to abjure all assistance from them, but simply to indicate that they may be deceptive. Such flowers as double primroses, and the strange developments on the corollas of some Gloxinias, may possibly receive their explanation from a careful study of the course of the vascular tissue. As the colour on the anterior and posterior order in the latter case is reversed, the doctrine of dedoublement does not at all help us.

Hofmeister, in his 'Handbuch der Physiologischen Botanik,' has an important chapter on free-cell formation, which at the present moment is of great interest as connected with Mr. Darwin's doctrine of Pangenesis. Mr. Rainey has showed that the formation of false cells takes place in the solutions of gum and other substances; and if this is the case where no vital agency is concerned, we may well be prepared for the formation of living cells in organizable lymph, or in other properly constituted matter. The curious cell-formation of Gum Tragacanth may be an intermediate case. Be this, however, as it may, we have examples of free-cell formation in the formation of nuclei, in the embryos of plants, and above all in the asci of ascomycetous fungi. In plants whose cells contain nuclei, new cells are never formed without the formation of new nuclei, the number of which exactly corresponds with that of the new cells.

It would be unpardonable to finish these somewhat desultory remarks without adverting to one of the most interesting subjects of the day,—the Darwinian doctrine of Pangenesis. After the lucid manner, however, in which this doctrine was explained by Dr. Hooker in his opening address, I should be inclined to omit it altogether had I not looked at it from a somewhat different point of view, so that I should not be trespassing upon your time in going over the same ground. Others, indeed, as Owen and Herbert Spencer, have broached something of the kind, but not to such an extent; for the Darwinian theory includes atavism, reversion, and inheritance, and embraces mental peculiarities as well as physical. The whole matter is at once so complicated, and the theory so startling that the mind at first naturally shrinks from the reception of so bold a statement. Like everything, however, which comes from the pen of a writer whom I have no hesitation, so far as my own judgment goes, in considering as by far the greatest observer of our age, whatever may be thought of his theories when carried out to their extreme results, the subject demands a careful and impartial consideration. Like the doctrine of

natural selection, it is sure to modify, more or less, our modes of thought. Even supposing the theory unsound, it is to be observed, as Whewell remarks, as quoted by our author, "Hypotheses may often be of service to science when they involve a certain portion of incompleteness, and even error." Mr. Darwin says himself that he has not made Histology an especial branch of study, and I have therefore less hesitation, though "impar congressus Achilli," in expressing an individual opinion that he has laid too much stress on free-cell formation, which is rather the exception than the rule. Assuming the general truth of the theory, that molecules endowed with certain attributes are cast off by the component cells of such infinitesimal minuteness as to be capable of circulating with the fluids, and in the end to be present in the unimpregnated embryo-cell and spermatozoid, capable either of lying dormant or inactive for a time, or, when present in sufficient potency, of producing certain definite effects, it seems to me far more probable that they should be capable under favourable circumstances of exercising an influence analogous to that which is exercised by the contents of the pollen-tube or spermatozoid on the embryo sac or ovum, than that these particles should be themselves developed into cells; and under some such modification I conceive that the theory is far more likely to meet with anything like a general acceptation. Be this, however, as it may, its comprehensiveness will still remain the same. We must still take it as a compendium of an enormous mass of facts, comprised in the most marvellous manner within an extremely narrow compass.

I shall venture to offer a very few words in conclusion, which perhaps may be thought to have too theological an aspect for the present occasion.

It is obvious how open such a theory is to the charge of materialism. It is an undoubted fact, however, that mental peculiarities and endowments, together with mere habits, are handed down and subject to the same laws of reversion, atavism, and inheritance as mere structural accidents, and there must be some reason for one class of facts as well as the other; and whatever the explanation may be, the hand of God is equally visible and equally essential in all. We cannot now refer every indication of thought and reasoning beyond the pale of humanity to blind instinct, as was once the fashion, from a fear of the inferences which might be made. Should any one, however, be still afraid of any theory like that before us, I would suggest that man is represented in Scripture as differing from the other members of the animal world, by possessing a spirit as well as a reasoning mind. The distinction between ψυχὴ and πνεῦμα, which is recognized by the Germans in their familar words *seele* and *gist*, but which we have no words in our language * to express properly, or in other terms between mere mental powers which the rest of the creation possess in greater or less degree in common with ourselves, and an immortal spirit, if rightly weighed, will perhaps lead some to look upon the matter with less fear and prejudice. Nothing can be more unfair, and I may add unwise, than to stamp at once this and cognate speculations with the charge of irreligion. Of this, however, I feel assured that the members of this Association will conclude with me in bidding this great and conscientious author God-speed, and join in expressing a hope that his health may be preserved to enrich science with the results of his great powers of mind and unwearied observation.

Botany and Zoology.

On the Structure of Coppinia arcta.
By Professor George J. Allman, *M.D., F.R.S.*

There is a peculiar production which grows in the form of small sponge-like masses on the stems of the larger hydroids, and is especially abundant on *Plumularia falcata* and *Sertularia abietina* from deep water.

For the first published description of it we are indebted to Sir J. G. Dalyell,

* A proof of this poverty of language is visible in the words used in our translation for ψυχικὸν and πνευματικὸν—natural and spiritual, their proper meaning in conjunction with σῶμα, being a body with a soul, and a body with a spirit.

who, recognizing its hydroid relations, placed it in the genus *Sertularia* under the name of *S. arcta*.

It was afterwards described by Dr. Hassall, who insisted, with reason, on its claims to constitute the type of a new genus, to which he gave the name of *Coppinia*.

The *Coppinia arcta* is now familiar to every student of the Hydroida, but some of the most interesting points in its structure have been entirely overlooked, and we do not possess even a correct diagnosis of its genus.

The two principal portions which, even on a superficial inspection, are seen to enter into the composition of the hydroid have been recognized by Dalyell and others. These consist (1) of a continuous basal incrusting portion, and (2) of more or less curved cylindrical tubes, which project from the free surface of the incrusting portion. It has further been shown that these tubes contain each a hydranth provided, in some cases at least, with a verticil of tentacles surrounding the base of a short hypostome, and in such cases capable of protrusion from the tube and of retraction within it. The tubes are thus true hydrothecæ. The hydranths are conspicuous by their fine lemon-yellow colour.

The incrusting base, however, has been entirely misunderstood, and yet its structure is full of interest. The hydrothecal tubes can be traced through it to its attached surface, while vertical and transverse sections show that the rest of the crust is composed of vertical chitinous tubes rendered polygonal by mutual pressure. They adhere to one another by their sides, and each opens on the free surface of the crust by a small circular orifice, which had been already pointed out by Dalyell.

These tubes are true gonangia. Within each is a solitary gonosac which buds apparently from a blastostyle, which, however, has been more or less suppressed by the growing gonosac. A sufficiently obvious spadix may be recognized in the gonosac, and between it and the walls of the female gonosac lies a single large lemon-yellow ovum. In this ovum, during its earlier stages, may be seen a distinct germinal vesicle, in which the place of the germinal spot is occupied by numerous clear spherical bodies, which disappear in a few seconds after the ovum is liberated from the gonosac and exposed to the influence of the surrounding water.

Segmentation commences while the ovum is still within the gonosac, and the ovum becomes thereby converted into a granular plastic mass, which is now forced out through the orifice in the summit of the gonangium. It carries out with it, however, a hernial extension of the attenuated walls of the gonosac, which form for it an acrocyst, in which it remains still for some time confined. It ultimately, by the rupture of the acrocyst, escapes as a planula into the surrounding water. The planula and its development into a hydranth included in a chitinous tube have been observed by Dalyell.

Both hydrothecæ and gonangia spring from an adherent tubular and anastomosing fibre, without the intervention of a distinct hydrocaulus.

A knowledge of the structure of *Coppinia arcta* will enable us to give a more correct generic diagnosis than was possible as long as we were ignorant of the true nature of this curious hydroid. The following may be taken as expressing the essential characters of the genus:—

Trophosome.—Hydrocaulus absent; hydrothecæ tubiform, sessile upon an adherent retiform hydrorhiza, and having their proximal extremities plunged into the mass of the incrusting gonosome; hydranths with a single verticil of filiform tentacles.

Gonosome.—Gonophores adelocodonic; gonangia tubiform, forming by the approximation of their sides a continuous incrusting mass surrounding the bases of the hydrothecæ, which emerge from it at intervals.

On the Occurrence of Erysimum orientale *under peculiar circumstances at Edinburgh. By* Professor T. C. Archer.

This plant was found during the present year in a garden situated in the Old Town of Edinburgh. The circumstances attending its appearance were remarkable.

A few wheelbarrows full of soil were gathered from the garden generally in order to make a hot-bed, and covered with a glass frame. The heat was communicated by a flue, and shortly after the bed was formed, and before any seeds were sown in it, plants of the *Erysimum orientale* began to spring up in considerable numbers, apparently developed by the heat of the flue. None appeared elsewhere in the garden, although the summer was unusually warm. From whatever sources the seed came, it would seem that in this locality more heat than the summer afforded was necessary to their germination in Scotland, where this is the first recorded instance of its appearance. A specimen in flower and seed was forwarded to Professor Balfour for exhibition.

Notice of the Occurrence of Hieracium collinum (*Fries*) *in Selkirkshire, with Remarks on some recent Additions to the Scottish Flora. By* Professor Balfour, *M.D., F.R.S.*

The author gave an account of some recent additions to the Scottish flora. He stated that *Hieracium collinum* (Fries) had been gathered in June last on the banks of the Ettrick, between Selkirk and Philiphaugh. This plant belongs to a section of the genus *Hieracium*, not previously represented in Britain. The plant was evidently in a wild station. The author gave a description of the species, and exhibited specimens. He also noticed the occurrence of *Medicago denticulata* at Dumfries and Melrose. This plant had not been recorded previously as a Scotch plant. Among other new Scotch plants exhibited were *Polycarpon tetraphyllum*, from the neighbourhood of Melrose, and a peculiar form of *Luzula* from the vicinity of Peebles. He stated that *Xanthium spinosum* was becoming naturalized in many places.

Remarks on the Properties of Atropa rhomboidea (*Hooker*), *in Connexion with its Botanical Character. By* Professor Balfour, *M.D., F.R.S.*

The author exhibited fresh specimens of a plant which had been cultivated for many years in the Royal Botanic Garden, Edinburgh, under the name of *Atropa rhomboidea* (Hook.). It was discovered by Gillies at Buenos Ayres, and is figured in Hooker's 'Botanical Miscellany,' vol. i. The plant is herbaceous, leaves pubescent, rhomboidally oval, blunt; peduncles 1-flowered, cernuous; æstivation of the corolla induplicate; anthers subexserted; embryo spirally curved. The stamens are higher up in the tube of the corolla than in *Atropa Belladonna*, and the inside of the tube of the corolla and the middle of the style have a belt of woolly hair. The flowers are small, of a greenish-yellow hue. The plant does not appear to be truly Atropaceous. It wants the imbricate æstivation of that order. Moreover, it was found that the juice of the plant had no power of causing dilatation of the pupil, which may be said to be characteristic of Atropas. In these circumstances the author was disposed to think that further examination of the plant was necessary.

On the Geographical Distribution of the British Genera of the Sessile-eyed Crustacea. By C. Spence Bate *and* Professor Westwood.

On the Crested or Top-Knotted Turkey. By A. D. Bartlett.

Specimens of the true *Allium carinatum*, L., were laid on the table by the Rev. M. J. Berkeley, which were gathered by the late Rev. W. S. Hampson, amongst rushes and coarse grass, in a lane in the neighbourhood of Stubton, in the county of Lincoln, where it was found in great abundance. The plant, which is figured under that name in 'English Botany,' is a mere variety of *Allium oleraceum*.

Specimens of Fungi, prepared by Mr. English, of Epping, were exhibited by the Rev. M. J. Berkeley, which were greatly admired from the perfect manner

in which the habit and the minutest details of the gills were preserved. The precise method by which they are prepared has not at present been made known. The two groups, consisting of numerous species, were deposited in the Museum at Norwich.

On Arboriculture as a Science. By William Brown.

After referring to what he advanced on the same subject at Dundee last year, the author said that the practical observer and man of science agree in the belief that man, to a great extent, can control and regulate certain climatic agencies. He quoted Sir John Herschel in attestation of this, showing that it is in man's selection of the kind of *vegetation* that such influences are perceptible. The gist of Mr. Brown's argument last year was that, by a proper distribution of variously-sized plantations, man may come to suit, in degree, the climate to the plant, and not so much the plant to the climate, as he must do in present circumstances. Reference was also made to Mr. Symons's paper in 1865, on the Rainfall of the British Isles; and it was shown that, narrow as Britain is, its climate is materially influenced by *local* causes—these causes having respect to the area of surface occupied by trees. It is sometimes said, "Give me a good soil, and I will produce abundant crops;" but this sole condition as to quality of soil is not enough; for a favourable climate is even more important than a rich soil. It is a fact that, as regards the *primitive* soil, there is no difference betwixt the slopes of the Himalaya (where the Deodar and broad-leaved oak luxuriate) and a great part of Scotland, the soil in each case being principally from granite and mica-schist. The succession of pine to oak, or beach to pine, in indigenous forests, has no doubt depended more on changes of temperature than any other physical cause. The author then showed that the geographical distribution of rain cannot meet the requirements of all parts of a country, and thus the need of those modifying circumstances which man can command being brought into play; for while it is beyond his power to interfere with the periodicity of events, to *modify* them certainly is not. Mr. Symons acknowledges that "rainfall records evince a regularity not before expected." The observations of half a century make it clear that the rainfall of these isles is, for all practical or general purposes, a *regular* one. The present extent under wood in Great Britain would make a belt two miles broad all round the coast, which seems large, and might suffice both for health, shelter, and climatic uses, but it is not distributed to suit the different requirements of districts. Until this is done it is perfectly plain we will never secure adaptable climates, or make meteorology practically useful. But with the knowledge of these two facts (the general *regularity* of rainfall, and that *local irregularities* are governed mainly by *local influences*), are we still to carry on the same plan of observing, recording, and deducing? Is it not time to amend our course of procedure in relation to atmospheric science? The author proposed that a set of direct experiments should be established to test the deductions drawn from the general ones, which, if properly conducted, would doubtless lead to important results, and would at once lay the foundation for a new era in the history of our rural economy. The question which he set before meteorologists was—at certain geographical positions, exposures, altitudes, and on certain geological formations, with and without artificial drainage, to what extent, and in what way, do trees and other vegetation exert their influences? The author concluded his paper by claiming for arboriculture a more prominent place under botany in connexion with the Association.

On the Progress of Oyster and Salmon Cultivation in England. By Frank Buckland.

The author stated that, in his official capacity as Inspector of Salmon Fisheries, he had lately visited most of the rivers of England and Wales. The supply of salmon had been much increased owing to the protection of the Acts of Parliament. Still there remained much to be done. He complained bitterly of the impediments caused by weirs, which prevented the parent salmon ascending to the spawning-grounds. The author instanced Diglis weir, which was the "hall door"

of the great Severn; Chester weir, that blocked the Dee; Tadcaster weir, on the Wharfe, &c. Besides these large weirs, there were mill-weirs innumerable on most salmon rivers which would otherwise be highly productive. The study of salmon-ladders was of the greatest importance. He exhibited several models of ladders which might be applied to weirs at a reasonable cost, and without interfering with the water supply. The question of pollutions was a very serious one, not only for the fish, but also for the public health. He instanced the Dovey, the Tees, the South Tyne, &c., which were suffering under "hush" from the lead mines; the Fowey, the Camel, &c., which suffered from the débris of China-clay works and other mines; and he deprecated the habit of allowing chloride of lime to run into the rivers. Paper-makers were great culprits in this matter. The law of pollutions should be made much stronger. He earnestly requested the attention of the Section to the question of "close time" for salmon, as the evidence went to show that the Welsh, Cornish, and Devonshire rivers were "later rivers" than the Severn, Dee, Tay, Wye, &c. Mr. Buckland then expounded his theory as to the cause of the failure of oysters for the last six years. The cause of the success this year, he considered, was warm weather and tranquil water. He had published, in 'Land and Water,' temperatures taken daily, during the months of June, July, and August, at five different oyster fisheries. The results, he thought, confirmed his theory. He had obtained a heavy fall of spat at his experimental fishery at Reculvers, near Herne Bay. There had also been a fall of spat in the rivers Crouce, Roach, and on the grounds of the Herne Bay Oyster Company, but he believed that the Colne and the Blackwater had not been so favoured. The author called the attention of the public to his "Museum of Economic Fish Culture," at the Horticultural Gardens, Kensington. The author had hatched and sent away to different rivers nearly 40,000 salmon and trout last year; and in his collection would be found models, coloured casts of most of the economic fish, fishing-nets, and other implements connected with the improvement of British fisheries, as well as a series showing the growth, development, and natural history of oysters. Samples of oysters from nearly all the British oyster fisheries were also exhibited.

On the Distribution of the principal Timber Trees of India, and the progress of Forest Conservancy. By Dr. Hugh Cleghorn.

When the British Association met at Edinburgh in 1850, a committee* was appointed to consider "the probable effects, in an economical and physical point of view, of the destruction of tropical forests." Their report was presented in 1851 at Ipswich, and is printed in the volume for that year. Attention was thus directed in India to the importance of preserving every influence which tends to maintain an equilibrium of temperature and humidity, of preventing the waste of valuable material, and the special application to their various uses of the indigenous timbers of the country.

A few years later, forest establishments were sanctioned in British Burmah (1855), and in the Madras Presidency (1856); and in 1864 Government laid the foundation of an improved general system of forest administration for the whole Indian Empire, having for its object the conservation of state forests, and the development of this source of national wealth. The appointment of Inspector-General of Forests was made, and it is now held by Dr. D. Brandis, formerly the able conservator in British Burmah.

The executive arrangements were left to the local administrations, general principles being laid down, the most important of which is that all superior Government forests are reserved and made inalienable, and their boundaries marked out to distinguish them from waste lands available for the public. Act 7 of 1864, defining the nature of forest rules and penalties, has been adopted by most of the local Governments.

Valuation surveys have been made to obtain reliable data as to the geographic

* The late Dr. Forbes Royle, King's College, London; the late Colonel R. Baird Smith, R.E.; Colonel Richard Strachey, R.E.; Dr. H. Cleghorn, F.L.S.

distribution of the more valuable trees, the rate of growth, and the normal yield of the forests.

Bengal.—In British Sikkim and the Dooars of Bootan there are large tracts of Sál (*Vatica robusta*), not yet surveyed. The produce of these forests is required for any extension of the Eastern Bengal Railway which may be determined upon, and for the doubling of the East India line now in progress. In the Darjiling district the higher slopes above 6000 feet have been reserved, and plantations both of temperate and subtropical trees have been formed. In the Terai several thousand mahogany trees have been planted out—raised partly from seed naturalized at the Calcutta Botanic Garden, and partly from seed received from the West Indies through the Colonial Office and Dr. Hooker, Director of the Royal Gardens, Kew. In Bengal the department had for two years the great advantage of being supervised by Dr. Thomas Anderson, whose botanical knowledge was of special value in the exploration of the little-known forests in Sikkim and Bootan.

North-West Provinces.—The recent surveys have added much to our knowledge of the forest resources of the north-west provinces. In Kumaon and Gurhwal the area surveyed is about 400,000 acres; a large part of this is covered with *Pinus longifolia*, bearing an average of fifteen trees per acre. The Himalayan Box is plentiful in certain localities, and has come into use in the schools of art for wood engraving. The Goruckpore forests cover 120,000 acres, and consist mainly of Sál (*Vatica robusta*), with an average of twenty-five well-grown trees to the acre.

The northern limit of indigenous Teak is in Bundlekhund; it has been planted in the Punjab, but in that dry climate it is poor and stunted. The management of the forests of the north-west provinces is second in importance only to that of Burmah.

Oudh.—From the survey in Oudh it appears that more than half of the Government forest consists of Sál; the other reserved woods of greatest value are Sissoo (*Dalbergia Sissoo*), Toon (*Cedrela Toona*), and Ebony (*Diospyros Ebenum*). Considerable sums have been expended in clearing the Sál trees of destructive twining plants, particularly *Bauhinia Vahlii*, *Argyreia speciosa*, and other *Convolvulaceæ*.

Punjab.—In the Punjab, the forests growing on the banks of the Five Rivers have been formed into so many ranges under skilled officers, and timber operations have been conducted with more or less success in the intra-montane districts. Long leases of the Deodar forests, in the territories of the Rajahs of Chamba and Bussahir, have been negotiated. Wood is the only fuel at present available in quantity for locomotive purposes. The requirement of the railway alone is estimated at 50,000 tons annually, and the yield of the old skikargahs, or fuel reserves, being inadequate, skilled management has been brought to aid the increased production of fuel.

Selected tracts have been trenched and ploughed before planting, and cattle and camels are strictly excluded. The services of two trained foresters have been secured. The suitability of some Australian trees to the arid plains of the Punjab is remarkable, and several species of *Acacia*, *Casuarina*, and *Eucalyptus* have been tried with apparent success. The northern limit of the Sál is on the bank of the Beas River, in the Kangra Valley, but here it is small and stunted.

Dr. J. L. Stewart is the conservator of the Punjab forests; he has contributed some valuable papers to the Journal of the Agricultural and Horticultural Society of India, as "Tour in Hazara and Khagan," "Flora of the Peshawur Valley," and "Bijnour and its Trees."

Central Provinces.—In the central provinces, the revenue settlement was proceeding when the Forest Department was sanctioned, and the demarcation of reserved tracts took place simultaneously, which was a great advantage. Six ranges have been established, and Teak plantations have been commenced on the Taptee and Nerbudda Rivers, and are to be steadily pursued on the plan of the Conolly plantations in Malabar. Two trained foresters from Scotland have been employed for some time. The attention of the department in this province is directed equally to Teak and Sál timber. The other reserved woods are Sissoo (*Dalbergia Sissoo*), Saj (*Terminalia tomentosa*), and Bijasal (*Pterocarpus marsupium*).

Hydrabad.—The forest operations have been more recently undertaken in the Hydrabad assigned districts. The character of the vegetation resembles that of

the Central Provinces, and the same species of trees are reserved. The only Teak tract is at Mailghat, north of Ellichpore, and it is carefully preserved.

Mysore.—The territories of the Rajah of Mysore have always been famous for Sandalwood and Teak; the former occupies a remarkable belt about 30 or 40 miles inland from the crest of the Ghats, though fine self-sown patches are diffused over the whole tableland. In the adjoining district of Salem, a considerable quantity of Sandalwood has lately been discovered in the Collamully and Putchamully Hills, and two small patches occur in South Canara, but these are at a lower elevation, and the timber is inferior in quality. The western part of Mysore is clothed with fine forest, but much has of late given place to coffee culture. *Tectona grandis*, *Dalbergia latifolia*, and *Calophyllum elatum* (Beddome) furnish the most valuable timbers.

Burmah.—The progress of forest administration in British Burmah has been steady, with a large increase in the forest revenue. In 1864-65 nine Teak forests were demarcated in the Tharawaddee division; the aggregate area of these is about 50 square miles. The necessity and importance of forming plantations is becoming every year more apparent. A recommendation to plant on a large scale was made forty years ago by Dr. Wallich, and afterwards by Dr. Helfer. It was again strongly urged by Sir A. Phayre and Dr. Brandis, in their joint report of June 1864, and planting is now systematically carried out. There are eight Teak plantations, which are being added to by annual increments, and planted in different ways to test the expense which must be incurred in raising Teak on a large scale. The facts recorded in the last report as to the germination of seed from different localities, and the measurement of growth of young trees, are interesting for comparison with the results obtained in Malabar and in Java. Further experience in management is annually gained, and it will be ascertained how far the same system is applicable to different provinces.

In Arracan, the most valuable timber is the *Inga xylocarpa*, termed Ironwood, from its exceeding hardness. The wood has been found useful for railway sleepers, and is exported to Bengal.

Madras.—The forests of Madras have for twelve years been under the care of a special department. The most valuable timber is Teak, which is to the south of India what Deodar is to the north, and Sál to the central provinces. Energetic efforts are being made to restore the woods in this Presidency, and very extensive plantations are formed, particularly in Malabar and South Canara (Teak), Neilgherries (*Eucalyptus* and Australian *Acacia*), Cudapah (Red Sanderswood), Shevaroys (Toon and Teak), and Sigur (Sandalwood). By far the most important of these are the Conolly Teak plantations in Malabar, which are rapidly increasing in value by the growth of the old plantation, and the annual increment of fresh planting. In 1866-67, 120,000 seedlings were planted out. The consumption of wood for railway fuel is enormous; a special train laden with wood for locomotives leaves Coimbatore, and another leaves Cudapah every day, in addition to the regular trains taking in wood at fuel stations. The natural jungles, which have hitherto supplied this large quantity, are in some districts so nearly exhausted that the mere protection of those which now exist will not yield a permanent supply. The natural reproduction of the indigenous jungles (where cattle are excluded) is expected to furnish a large supply of fuel, but it is further intended to form plantations for locomotive requirements. These, in accordance with the instructions of the Secretary of State, are to be under the management of the Forest Department, and their cost to be a charge in that department. These operations involve present and prospective outlay, with no returns till after the lapse of seven or eight years. This important branch of forest work must increase with the extension of railways, and it is hoped that the example set by Government may have the effect of stimulating private individuals to form similar plantations. The financial condition of the forest department in Madras is so far satisfactory. The total net surplus in eleven years, including the value of timber in store on 30th March 1867, is £180,000, or from £15,000 to £20,000 a-year. Within the last few years much has been done in the way of improving forest communications in remote and difficult places. Major Beddome, at present in charge of the forests, has done much for science, and is well known by his work on Indian Ferns.

Bombay.—In the Presidency of Bombay the forest department is of old standing. Mr. N. A. Dalzell succeeded Dr. Gibson, the first conservator, and is an accomplished botanist. For some years the receipts have exceeded the expenditure by several lakhs, say, £30,000 annually. The demarcation of reserves in the Deccan has been in progress, and is a most important measure. The administration of the forests in Sind has received the commendation of Government. The demand for firewood for large towns, steamboats, and railways has augmented very considerably, showing the absolute necessity of husbanding the resources, so as to keep up a regular and abundant supply of fuel. *Acacia arabica* is the tree which thrives best in Sind, and the timber is much prized for many purposes.

The importance of continuing the forest surveys and of demarcating the reserved tracts was urged, and the want of a *Flora sylvatica* of India insisted upon.

On some of the Principal Modifications of the Receptacle, and their Relation to the "Insertion" of the Leaf-organs of the Flower. By ALEXANDER DICKSON, *M.D., Regius Professor of Botany in the University of Glasgow.*

The author called attention to some of the principal modifications of the receptacle affecting the "insertion" of the leaf-organs of the flower, which may be classed as follows:—

A. Modifications with superior ovary.
- (*a*) Floral envelopes and stamens hypogynous: ex. *Nuphar*, &c.
- (*b*) Floral envelopes perigynous (*i. e.* inserted on a more or less cup-shaped expansion of the receptacle); stamens hypogynous: ex. *Passiflora*, &c.
- (*c*) Floral envelopes and stamens perigynous: ex. *Prunus*, &c.

B. Modifications with inferior ovary.
- (*a*) Receptacle not expanded or prolonged beyond the flower; floral envelopes and stamens simply epigynous: ex. *Hedera*, &c.
- (*b*) Receptacle expanded beyond ovary as a cup or tube, bearing the floral envelopes and stamens, which may here be said to be peri-epigynous: ex. *Fuchsia*, *Victoria*, &c.
- (*c*) Receptacle prolonged beyond the ovary as a stalk-like process†, expanded at its extremity into a small cup which bears the floral envelopes and stamens, which here may be called hyper-peri-epigynous: ex. *Circæa*.
- (*d*) Floral envelopes simply epigynous. Within these the receptacle is prolonged as a stalk, bearing the stamens and the true style (here almost reduced to stigmatic portion) at its extremity. The stamens may be here called hyper-epigynous: ex. *Stylidium*.
- (*e*) Floral envelopes hypogynous; stamens epigynous: ex. *Nymphæa*.
- (*f*) Calyx hypogynous; corolla and stamens epigynous: ex. *Codonopsis cordata*.
- (*g*) Calyx hypogynous; corolla and stamens peri-epigynous: ex. *Barclaya*.

C. Aberrant forms where the receptacle exhibits pit-like cavities or spur-like dilatations. Ovary superior or inferior.

* Pits or spurs occurring between the insertion of the petals and that of the stamens.
- (*a*) One receptacular pit (posterior); posterior sepal and two posterior petals perigynous; ovary superior: ex. *Pelargonium*.
- (*b*) One receptacular spur (posterior); posterior sepal, one-half of each lateral sepal and two posterior petals (or sometimes the entire floral envelopes) perigynous: ex. *Tropæolum*.
- (*c*) One pit in receptacular prolongation beyond the ovary; stamens hyper-epigynous, somewhat resembling those in *Stylidium*: ex *Semeiandra*.

** Pits occurring between the insertion of the stamens and that of the carpels.

† Such a stalk is, of course, not solid in a morphological sense; but is, potentially at least, a tube whose cavity is continuous with that of the style.—A. D.

(*d*) Several symmetrically disposed pits in the wall of the inferior ovary: ex. *Monochætum*, &c.

(*e*) One receptacular pit; ovary superior: exs. *Brownea, Tamarindus, Jonesia*, &c.

[(*f*) One pit in prolongation of receptacle beyond the inferior ovary: ex. *Quisqualis*. This was omitted when communication was read.—A. D.]

Experimental Studies on Annular Incisions on Mulberry Trees.
By Professor E. Faivre.

The following propositions are the result of the experiments which the author has made for several years:—

1. Annular incisions on mulberry trees produce general or local effects. The general effects consist at first in a greater activity given to the growth above the parts in which the incision has been made, then in a gradual diminution of the growth, the consequence of which is the destruction of the branches upon which the operation takes place. The local effects consist—

A. In the alteration of the ligneous layers which have been deprived of the protective influence of the bark.

B. In the ordinary production of a reparative "bourrelet" on the upper lip of the incision.

C. In the growth of the branch above the incision.

D. In the production of shoots more or less vigorous under the inferior lip of the incision; occasionally in the production round this inferior lip of a small "bourrelet."

2. The time in which the incision is made has a great influence on the effects produced. The reparative tissue and the growth above the incision are essentially connected with the state of vegetation. If the vegetation is suspended by winter, no "bourrelet" is visible, and growth is at a standstill; on the contrary, if the vegetation is active as in summer, and especially in spring, the formation of the reparative tissue is easy and rapid. The formation of the "bourrelets," in all times of healthy vegetation, testifies to a continuous activity in the circulation of the sap.

3. The incision differs in its effects according as it is made upon the stem or root, or the young herbaceous shoots or branches of several years' growth.

The incision made on the stem causes the destruction of the parts situated above the incision, whilst the incision made on the root destroys the parts above the incision.

The "bourrelets" then are situated on the destroyed parts, in the case of stems or branches, but, on the living parts, in the case of roots.

The incision made on the root causes a growth of numerous small roots; this development (of small roots) has become practically useful.

If the branches subjected to incision are young and herbaceous, the formation of the "bourrelet" is quicker, and the destruction of the superior parts is less likely than if the operation were performed on ligneous branches.

These results may be practically applied to the propagation of cuttings.

4. The presence or absence of leaves has great influence upon the formation of a "bourrelet" and the production of small roots, and on the healing of the wound made by the incision. The absence of leaves produces the absence of a reparative "bourrelet."

Hence the leaves manifestly influence the elaboration and the descent of sap, to which the formation of a "bourrelet" is due. The influence of the leaves on the nutrition of the roots is an important and practical consequence on the aforesaid facts.

5. The age of the branch operated on, and the depth of the incision, modify remarkably the results of the operation. If one operates on a small ligneous branch of two or more years' growth, on the removal of the surrounding ligneous layers, if the annulation is made in the summer, the leaves fade in one or two days, the branch dies, and no "bourrelet" can be formed. If one operates in the same man-

ner on an herbaceous shoot, the operation is not fatal, the leaves continue healthy, the part of the branch above the incision survives a long time, and a "bourrelet" may be produced.

The author has, by experiment, established that these different results are due to the ascent of sap through all the ligneous layers in the herbaceous shoots, and only through the exterior layers in shoots of two years or more.

6. The positions given to the incision have a real influence on the consequent physiological phenomena; thus the partial incisions made, one above the origin of a branch, another under the origin of a branch (*i. e.* if subject to the same conditions), cause in one branch the formation of a voluminous "bourrelet" on the superior lip of an annulation made above the first incision: in the other branch, if the incision is made under the origin of the branch, the "bourrelet" is scarcely visible.

Experiments already made on this subject indicate an evident relation between the ascent and descent of sap with respect to the quantity and the movements.

7. The nature of the *matter* with which the wound made by the incision is covered has an influence upon its healing. In applying the *mastic* employed in grafting, either to the branches in a normal state or to the cuttings, we have discovered that it quickens the vegetative power in the branches, and prolongs it, but does not ensure their preservation. India-rubber acts more efficaciously; it accelerates considerably the formation of the reparative tissue, and its use might be recommended in horticulture.

8. The starting-point of the effects of annular incision is the alteration of the ligneous layers exposed to the air and to evaporation, in consequence of the removal of the bark. The ascent of the sap can no longer take place through the wounded tissues, hence the leaves fade, the course of the descending sap is impeded, and finally suspended; consequently the formation of the reparative tissue becomes impossible. Such is the mechanism which seems to the author to explain more rationally the facts, at any rate, concerning stems and small branches.

On a new British Moss, Hypnum Bambergeri. *By* John Fraser, *M.A., M.D.*

One day towards the end of July 1867, while botanizing on Ben Lawers, the author found a moss which appeared to be new. It was afterwards submitted to Mr. Wilson of Warrington, Mr. G. E. Hunt of Manchester, Dr. Braithwaite, and others, all of whom were satisfied that it had not previously been observed in this country. It was the *Hypnum Bambergeri* of Schimper, which was discovered by Bamberger on the Stockhorn, Switzerland, afterwards on the Bavarian Alps, and in Norway. It was found by the author, not on low swampy ground, as might have been expected, but high up among the broken rocks, near the summit of the mountain. Its range appears to be from 3500 to 7000 feet, and its position in the genus *Hypnum* between *H. imponens* and *H. callichroum.*

The following is a pretty correct description of it:—It occurs in rather small dense tufts, yellowish-green above, passing to yellow fuscous at the base; stem without radicles, subpinnate, with a few fastigiate branches; leaves densely crowded, secund, strongly circinnate, ovato-lanceolate, elongated, entire, with a long ovate point; nerves two, faint, one usually longer than the other; alar cells few, rather obscure, yellow, upper ones linear, elongate, pale; fruit unknown, but female flowers not unfrequent.

Notice of a Male Octopodous Cuttlefish and some other Cephalopoda. By Robert Garner, *F.L.S.*

Amongst a parcel of Cephalopoda from Sardinia occurred a specimen of a male animal which the author thought possessed some interest. Were one not aware that the male Argonaut is a very diminutive animal, and also the curious process by which the eggs of the female are fertilized, one might have set down the specimen in question as the male of that mollusk. This cannot well be done, and therefore the author supposed it to be a species of *Tremoctopus,* and, indeed, it had aquiferous pores, at the base of the lowest arms or feet, leading into cavities above

the eyes. Of one species of *Tremoctopus* the male is known, diminutive like that of the Argonaut. The colour, spots, and texture in the specimen in question were the same as in the female Argonaut; whilst the aliform appendages to the feet, and the shape of the body moulded somewhat to the shell, were characters wanting in the specimen, but present in the Argonaut. It was no *Octopus*; it had, like the Argonaut, a very perfect mechanical arrangement at the base of the siphon for the inlet and exit of the water in respiration and progression; sockets to receive prominences within the margin of the mantle or sac, and the sockets themselves with cartilaginous hooks at the lower part to lock the mantle to them. The lingual ribbon was that of the Argonaut, not of the *Octopus*. The eyes and their lids or membranous coverings (which differ much in the whole tribe) were like those of the Argonaut, consisting of two crescentic portions of skin overlapping. There were not the little side cartilages to be found in *Octopus* or its ally *Eledone*; there were appendages to the branchial hearts absent in *Octopus* according to Cuvier, but not in *Eledone*, and not wanting in Argonaut; and lastly, there were two genital pores in the animal in question, though there is only one in the male *Octopus*; and the excretory ducts were not complicated and glandular in the former, whilst the single one is so in the latter. In fact the internal anatomy is in every respect the same in the specimen described as in the Argonaut. If a male *Tremoctopus*, the two genera must be very nearly allied. The stomach contained conical shells of Pteropoda, lingual spines of mollusks, and portions of the eyes of cuttles and fishes, such fragments as are commonly found in the stomach of the Argonaut. In the same parcel was a small Argonaut in its shell, which was less than three inches in length, but had a mass of ova in the spire, over which the winged arms were folded, and around them the fine extremities of the next pair of arms curled. In the ovaries of this and of another larger specimen, the author noticed a few threadlike bodies, an inch and a half long, tapering behind, and having a hair-like portion at the blunter extremity; he supposes these to be entozoa. *Sepiola Atlantica* occurred with the other Cephalopoda, therefore it is not exclusively an Atlantic species; it has eye-pores leading to the subocular glands. *Rossia microsoma* also occurred, its internal structure differing in nothing from the last. In both there is a clear membrane stretched over the eye with only a slight duplicature before and below; the ink-bag is somewhat quadrate in form, with two attached glands. There was a young and an old specimen of *Ommastrephes todarus*: in this species the tentacles are evidently not retractile; the eyeball is much exposed, having a large spade-shaped opening in the integument in front of the lens, whilst in *Loligo* it is covered over completely by a clear membrane; the pits at the base of the funnel are triangular, not linear as in *Loligo media*, which also occurred as a Sardinian species; *Eledone cirrhosus* and *Octopus vulgaris* complete the list of species. In both these the anterior chamber of the eye seems closed by an anterior, thicker, and posterior clear crescentic fold. Almost all Cephalopoda have ducts from the subocular gland opening externally, and very often other pores opening from cavities about the head.

Education in Natural Science in Schools. *By* T. B. Grierson, *M.A.*

Notice of Rare Fishes occurring in Norfolk and Lothingland. *By* T. E. Gunn.

The author, after describing the geographical situation of Norfolk as being especially favourable to the production of this class of animals, proceeded to notice what previous accounts relating to this subject had been placed on record by various authors. After briefly describing the valuable products of the fisheries as giving employment to a great proportion of the population near the coast, and noticing the subject of the whitebait and sprat, he proceeded to more fully describe the occurrence of the principal rarities, commencing with the accounts of Sir Thomas Browne, and noticing the fact that some species, apparently rare in his time, are now of common occurrence, instancing as familiar examples the two species, the lump-sucker and lamprey. Amongst the rarities enumerated are the

two giltheads, mailed gurnard, swordfish, pilotfish, sea-horse, trumpetfish, gemmeous and sordid dragonetts, anchovy, Ray's bream, plain bonito, opah, blue and fox-sharks, hammer-headed shark, sawfish, flyingfish, and many others. Of the hammer-headed shark, the head of the only specimen obtained in Europe of late years is now preserved in the Norwich Museum, and a single specimen of the sawfish was obtained off Lynn, in the time of Sir T. Browne, this being apparently the only instance on record of the occurrence of this species in the British seas. The flyingfish, *Exocetus volitans*, have on several occasions been observed in the British seas, and in about three instances have been captured, the last capture being off Yarmouth this last season; one of the pectoral fins of this specimen (now in the author's possession) was exhibited at the reading of this paper.

He next enumerated some singular malformed varieties, viz. double-headed haddock, whiting with three eyes, and a malformed basse.

A brief account of the river-fish, with remarks on some varieties of sticklebacks, &c., brought the paper to a conclusion.

The total number of species enumerated is 123, leaving a reasonable hope that when the subject is more fully investigated several further additions may be made to the Norfolk list.

On the possible introduction of South European Plants in the West and South of Ireland. By Professor HENNESSY, *F.R.S.*

The author's inquiries into the climatology of the British Islands had led him to examine the physical conditions which affect the distribution of vital phenomena in Ireland. So far back as 1860 he had already called attention to the relations between the peculiar distribution of the flora in the western districts of Ireland and the position of the isothermal lines in the map which he had previously published*. These relations have been pointed out more recently, and with more precision, in the map appended to a paper by Dr. David Moore and Mr. A. G. More, "On the Climate, Flora, and Crops of Ireland," in the Report of the International Horticultural Exhibition and Botanical Congress, held in London during May 1866. The author briefly presented geological and geographical grounds for rejecting the hypothesis of the late eminent naturalist, Professor E. Forbes, and he also adduced similar criticisms from other inquirers†.

The author next presented a summary of all the South European plants found in the West and South-west of Ireland, specifying minutely their localities both in Ireland and on the Continent. The former are limited to two coast districts bordered by numerous navigable inlets and fishing-grounds; namely, first among the maritime baronies of the counties of Galway and Mayo; and secondly, a part of Kerry, together with the south-western extremity of Cork. On the Continent the plants in question are abundantly found, as already remarked by Forbes, in the northern part of Spain, and especially the province of Asturias. The author calls these plants, for brevity, the Asturian flora; and the two districts where they are found in Ireland, the West Asturian and South-West Asturian districts, respectively. It has been admitted by Forbes that there does not seem to be evidence of any local assemblage of animals in these districts corresponding to the Asturian flora, and the inquiry is therefore entirely limited to discover the origin of the plants. The physical conditions accompanying the growth of the Asturian flora, both in Spain and in Ireland, are fully discussed. The climate of the province of Asturias is characterized by great moisture and a mild winter temperature; thus, at Oviedo, which is about the centre of the province, the mean annual fall of rain is nearly 75 inches, and the wettest months are April and May. The mean annual temperature is 55°·4 F.; the mean winter temperature, from 45°·4; the mean summer temperature is 65°·2; the mean yearly maximum is 88°; the mean yearly minimum from 31° to 34°.

The prevalent geological formations are stated to be Devonian and Silurian, and

* Atlantis, vol. i. p. 396.

† See D'Archiac's "Hist. des Progrès de la Géologie, publiée par la Société Géologique de France sous les Auspices du Ministre de l'Instruction publique," vol. ii. pp. 128–137; also Darwin's 'Origin of Species,' p. 354.

the soil is said to be generally retentive of moisture. Although the geology of the other provinces in the North of Spain is in some respects essentially different, there are good grounds for believing that their climate is similar to that of the Asturias. When we turn to the Asturian districts of Ireland, we find more features of geological and physical resemblance to the North of Spain than in any other districts of equal area in Ireland. The influence of climate, which seems of paramount importance in relation to plants, is very remarkable in the Irish Asturian districts. The author illustrated his views by reference to a Map, on which were projected the isothermal lines of mean annual and mean winter temperature for Ireland. These lines were drawn by the aid of observations made at some new stations, in addition to those on which he had to rely when projecting the isothermals already published. Among these stations he especially referred to Galway, from its position in the West Asturian district. From the Map, it appears that the greater part of the areas of both of the Asturian districts lie between the annual isothermals of 52° and 51°, and between the winter isothermals of 45° and 44°. These are the lines of highest temperature in Ireland, and the winter lines correspond almost identically with those belonging to the middle of the province of Asturias itself. On the other hand, the summer temperature of the Irish Asturian districts is from 57°·5 to 59°·3 respectively, and therefore from 6° to 8° lower than that of the North of Spain; whence it follows that if plants were introduced into an Asturian district from Spain, some of which required a warm summer, while others required only a mild winter, the former would die, while the latter might survive, and even spread over extensive areas. The condition of great summer warmth seems to be especially required for annuals belonging to southern climes, as the ripening of the seeds would be inevitably checked by a single cold and wet summer. The growth of perennials appears to depend principally on the condition of winter temperature, as these plants may spread by roots and suckers. After referring to the generally admitted fact of the moisture of the climate of Ireland, the author concludes, from observations made at Galway, Innishgort, in Clew Bay, and Lough Corrib, that the annual rainfall in the West Asturian district must at least exceed 50 inches; while observations made at Valentia, Killarney, Cahirciveen, and Castletownsend show that the fall is probably still greater in the South-west district.

Corresponding conditions exist with regard to the relative humidity of the air. If, as before supposed, different varieties of plants from a southern clime were by accident introduced into our Asturian districts, for some of which moisture was more favourable than to others, the former would have a far greater chance of becoming widely spread, while the growth of the latter might be checked instead of being promoted.

The influence of cultivation in promoting or checking the introduction of wild plants into the Asturian districts was next discussed. It appears from returns furnished to the Registrar-General of Ireland during five years, that the greatest proportion of weedy ground was observed in the Asturian districts; and from returns made during several years of the relative areas under tillage, pasturage, and in a totally uncultivated condition, that the Asturian districts were the lowest in general cultivation among districts of equal extent.

Although annuals and the class of weeds generally accompanying crops are at first favoured by culture, which opens the soil for their propagation, it seems that the tranquil development of perennial wild plants takes place most completely where culture is imperfect or entirely suspended; whence it follows that if any perennial wild plants suited by their habits to the Asturian district happened to be introduced into them, their chance of existing and spreading would be greater than in other districts of Ireland. In addition to the evidence furnished by the returns of the Registrar-General, the author referred to the writings of Arthur Young, and to the Agricultural Surveys of the counties of Ireland, in order to show that the same relative condition of the Asturian districts with reference to cultivation had been in existence as long as the subject had attracted any notice. It was shown by numerous references, that a great many well-authenticated instances of the introduction of plants through commercial and general intercourse have greatly changed the flora of different countries. These changes were often effected within a comparatively short period of time, and they were more or less complete in proportion

to the more or less favourableness of the climatic condition of the new stations of the introduced plants. After fully discussing these results, the author puts forward his views in the following propositions:—

During two periods of prolonged and intimate intercourse between the northern coast of Spain and the whole of Ireland, the conditions for bringing the seeds of various plants into the latter country from the former probably existed; and during the more recent of these periods, the existence of such trading and fishing intercourse between Spain and the Asturian districts of Ireland is so well established, and was of such a kind as to render the introduction of accidental seeds almost certain. Such seeds as required a warmer climate than that of Ireland for their germination necessarily failed, while those which were suited to the physical conditions into which they were thrown became naturalized. The winter isothermals, and the corresponding distribution of minimum temperature, confined the range of these plants to the two narrow littoral districts where they are found. The cold and wet summers which often exist in Ireland would speedily destroy such annuals as happened to be introduced from the warmer summer climate of the North of Spain; but a few of the perennials might still continue to exist, owing to the favourable conditions of winter temperature in the West of Ireland.

The author briefly discussed the grounds which we possess for believing in a former intercourse between Spain and Ireland at a very remote epoch; and he examines, with great minuteness and detail, the evidence of such intercourse during a more modern period. It appears that from the thirteenth to the sixteenth centuries inclusive, the west and south-west of Ireland were in close communication with the ports of Biscay and Asturias. Local histories and traditions, popular poetry, and unpublished documents were referred to in support of this conclusion; and it appears that many of the stations of the Asturian flora, where plants are actually found, were also trading or fishing stations of Asturian or Biscayan mariners.

In the two instances where names in the Irish language had been ascertained for the Asturian plants, these names, in the opinion of Celtic scholars, clearly indicate the introduction of the plants from foreign countries. It is also remarkable that one of the plants of the Asturian flora has been observed in other parts of Europe—namely, Belgium and the islands off the coast of Friesland, districts where the Spaniards had considerable intercourse before the Netherlands had finally achieved their independence. The winter climate of the Netherlands was probably not sufficiently favourable to the development of the other plants belonging to the Asturian flora, and these are therefore confined to those parts of Ireland where all the physical and social causes favouring their growth have long existed in a sufficiently high degree of intensity.

On the Wellingtonia gigantea, *with remarks on its Form and Rate of Growth, as compared with the* Cedrus Libani. *By* John Hogg, *M.A., F.R.S., F.L.S.*

The author commenced his paper with a brief historical notice of the discovery of this magnificent North-west American tree by Mr. Whitehead in June 1850, in the Calaveras Grove in California.

This grove is situated in a sloping valley on the mountain-ridge between the South Antonio branch of the Calaveras, and the north fork of the Stanislaus Rivers, in lat. 38° N., and long. 120° 10′ W., at an elevation of 4370 feet above the Pacific. Having traced the subsequent and fuller accounts of the finding of more of these immense evergreen conifers, by Messrs. Dowd and Lewis, Mr. Hogg enumerated some of the largest trees, and gave their dimensions, which are to be seen in the Calaveras Grove, to which he assigned the title of the "Original Grove." One of these, called the "Father of the Forest," measured 110 feet in circumference at the ground, and about 435 feet in height. It was shown that other trees of great size were also found in Crane Flat in Calaveras county, on one of the tributaries of the Big Creek, on an upper branch of the Frezno River, and in the Maripora Grove, between the Big Creek and the Marced. Also it appeared that in the year 1857 Mr. Clark came upon two smaller groves of the same splendid tree. And more recently an eighth and larger grove was noticed about twelve miles east of the Frezno Grove.

The author mentioned the names of some of the most remarkable of these "Mammoth Trees," with their dimensions, and stated that, instead of there being only *two* groves, as was at first supposed, there existed eight or nine in all; the whole of these localities are considered to possess from 1250 to 1300 trees.

He then adverted to the generic differences of the *Wellingtonia*—a name inappropriately given by the late Dr. Lindley, instead of the more proper one "Washingtonia."

Dr. Lindley, thinking that this conifer did not grow "above *two inches* in diameter in twenty years," being equivalent to 24 lines in twenty years, concluded that its age was 3000 years. In the year 1857 Mr. Hogg made another estimate of its age after having examined some of the breadths of the annual zones in a section of a part of the stem itself; and taking *three lines*, or a quarter of an inch in diameter, as its *mean annual* growth, especially as it is a tree of *quick* growth, this would make the tree to be 1344 years of age. So Dr. Torrey subsequently came to a very similar conclusion, from his own more accurate computation, that the tree had existed for 1200 years only, instead of 3000 years.

The author then remarked that that method of computation is not strictly to be depended upon; and that it is a question whether or not certain trees do undergo *two* growths in *every* year, or only in *certain* favourable seasons. Several botanists consider an *annual double* growth to be probable; and especially, with regard to the increase of the *Cedrus Libani*, M. Loiseleur Deslongchamps concluded that such was the case; and that each year presented *two* layers; the *one narrow* and hard, and the *second* much *broader* and looser.

Dr. Hooker visited in September 1860 the ancient Cedar Grove in Mount Lebanon, at the elevation of about 6000 feet above the Mediterranean; and he calculated from the concentric rings of a *branch* of an old tree, 8 inches in diameter (*without* its bark), which had "no less than 140 rings," the *youngest* trees in that valley of the Lebanon (Kedisha) would average 100, the *oldest* 2500 years in age. Both of these estimates, however, Dr. Hooker considered to be "wide from the mark."

Mr. Hogg compared the annual increase in height of a healthy young *Wellingtonia,* eight years old, with a *Cedar* of *Lebanon,* ten years of age, which was, according to Loudon, planted in a very favourable situation near London.

The *Wellingtonia,* growing in the south extremity of the county of Durham, was found to have increased in height in two years (when aged eight years) 3 feet 6½ inches, making it in July 1868 to be 7 feet 6½ inches in total height; whilst the young Cedar had only reached 7 feet in ten years.

The same able Dendrologist says that the Cedar of Lebanon "does not begin to produce cones till it is twenty-five or thirty years old," whereas this young *Wellingtonia* bore *two* cones and *one male* flower when six years of age, which was in June 1866; the last, or *male* flower, presented some scales with the anthers (small balls of an orange colour) placed within them.

The mode of growth with the young Cedar is by spreading out into *horizontal* branches, whilst that of the young *Wellingtonia* is pyramidal and *upright,* with all its lower portion beautifully branched. As the latter advances in age, it loses its lower branches for about one-third or more of its total height. Thus, in that colossal individual, the "Father of the Forest," it had lost its branches for about 200 feet from the ground; its entire height being 435 feet.

The author, in concluding, observed that the growth of large trees, and the formation of wood in the concentric zones or rings of the stems, required to be further and more attentively investigated, as it is a very important question in vegetable physiology.

Mr. Hogg illustrated his paper by copies of photographs of several *Wellingtonias;* and also one, representing a glorious primeval *Cedar,* taken last year in the Lebanon.

Notes on Two British Wasps, and their Nests, illustrated by Photographs. *By* JOHN HOGG, *M.A., F.R.S., F.L.S.*

The author exhibited three photographs of wasps' nests; all, except one, he had found at Norton, in the county of Durham, from the years 1831 to 1856, both

inclusive. The *first* Plate represented the interior of the largest nest of *Vespa arborea*? of Mr. F. Smith; and the *second* and *third* five nests of the *Vespa Britannica*, with four of the wasps taken out of them.

Plate II. exhibited the more delicate and exquisitely fabricated nests of the *Vespa Britannica* of Leach, or, as other entomologists term it, *V. Norvegica*.

On some Organisms which live at the bottom of the North Atlantic, in depths of 6000 *to* 15,000 *feet**. *By* Professor T. H. Huxley, *LL.D., F.R.S., F.L.S.*

On the Necessity of Photographing Plants to obtain a better knowledge of them. By Dr. Karl Koch.

The author drew attention to the advantage of photographs to the systematist for the comparison of plants. There are many plants of which the dry specimens in the herbarium are not sufficient, especially in the case of trees, where the best descriptions cannot give an idea of their physiognomy. The Liliaceous plants, and nearly all the Monocotyledons, in a dry state, give a bad view of their physiognomy. In the Botanic Garden and glasshouses at Berlin, such plants are cultivated which when photographed would give, more especially for monographers, good material for their description or their diagnosis. A collection of plant-photographs is being made at the Botanic Gardens at Berlin; and the author would thank possessors of gardens and greenhouses to send him photographs of interesting plants and trees. The author exhibited the photograph of an Aroideous plant, from which he was alone able to determine that the plant was new and to give a good diagnosis and description.

On the Specific Identity of the Almond and the Peach. By Dr. Karl Koch.

The author stated that he had travelled over the mountains of the Caucasus, Armenia, some parts of Persia and Asia Minor, during four years, for the purpose of studying the origin of our fruit-trees. Although the author could not assert that he had found them perfectly wild or run wild, he nevertheless had collected much interesting material. The author believes that our pears and apples, cherries, most plums, also peaches and apricots, are not natives of Europe. Only certain bad varieties of plums have their origin from *Prunus insititia*, the tree which grows in a wild condition in the woods of Europe. After discussing the wild stock of our cherries and pears, the author stated that apricots do not grow wild in Oriental countries, but may perhaps come from China and Japan, as also the peaches. In the east of Persia, however, a peach-shrub grows, which is intermediate between the almond and the peach-trees. For some time naturalists and gardeners have asserted that there is no difference between almond and peach-trees; that the latter is merely a variety in which the dry rind of the almond has become fleshy, and where at the same time the stone has acquired a rough surface. Botanists say also that the petioles of the almond-tree have at the superior end small glands, which are absent in the peach. But the nectarine, which is but a smooth-skinned peach, exhibits these same glands. The flowers are not readily distinguishable of peach and almond. On the shores of the Rhine a double-flowered variety grows, as to which it is not certainly known whether it is peach or almond. In England and France also there is a plant which is well known as the peach-almond, and which is a constant variety. This plant occasionally produces a branch bearing good peaches, but, as a rule, its fruit is intermediate in character. The property of atavism seems to prove the derivation of the peach from the almond; for occasionally a sound peach-tree will produce a branch bearing almond-like fruit.

On the Classification of the Species of Crocus†. *By* Dr. Karl Koch.

Most botanists have only made use of the flowers and fruits of plants in the for-

* Published *in extenso* in the Quarterly Journal of Microscopical Science for 1868.

† Published *in extenso* in the Gardeners' Chronicle, September 12, 1868.

mation of genera; we have thus obtained, not natural, but artificial groups. For the formation of natural genera it is always necessary to know also the vegetation and the habit, both of which are very often in intimate connexion with the flowers and fruits. The author has studied for a long time the crocuses and their vegetation. The flowers of these plants do not always furnish good characters; the proportionate length of the stamens and the style, on which botanists lay great value, is only relative, and is not always sure. Better characters for the great divisions are to be drawn from the vegetation. The author has observed that many crocuses twist the leaves spirally when they are dry. The same crocuses have also a corm in which the scales or the sheaths are cut across transversely at the base. In this tribe of crocuses are found blue, purple, white, and yellow flowers, as in the other tribes, where the leaves are straight, and so tenacious that they can be used as twine. The corms of the latter have the scales minutely or strongly reticulated.

The author gave another example where the vegetation is of the greatest value for the systematist. Besides the leaves, the sheaths of the corms of the crocuses are also very important. He distinguished by this means four groups; first, crocuses with corms in which the scales are circumscissile near the base; secondly, crocuses where the scales are furnished with long and straight nerves; thirdly, crocuses where the scales or sheaths are finely, or, fourthly, where they are strongly reticulated.

The bracts and the number of the flowers give also good marks for the distinction of the species; we have crocuses with one and with two bracts, and with one or many flowers. When the author has finished his observations about the fruits and seeds, he hopes to publish a treatise on the subject.

Notes on the Flora of Skye.

By M. A. Lawson, *Professor of Botany in the University of Oxford.*

During a short stay of a fortnight in the Isle of Skye in company with Professor Oliver and Mr. H. S. Fox, the author drew up a list of all the plants that came under their notice, and, since his return, compared it with others of the neighbouring islands and mainland. Of this comparison the following is the result.

Of the 389 species he found in Skye, the following 31 have never been recorded from the subprovince 32 of the Supplement to the 'Cybele Britannica:'—

Nymphæa alba.
Draba incana.
Arabis petræa.
Prunus padus.
Rubus cæsius.
—— umbrosus, *Arrh.*
—— corylifolius.
Epilobium anagallidifolium.
Myriophyllum alterniflorum.
Ribes rubrum, var. spicatum.
Galium uliginosum.
Apargia hispida.
Hieracium anglicum.
—— iricum.
Arctium minus.
Carduus nutans.
Vaccinium oxycoccus.
Veronica montana.
Ajuga reptans.
Galeopsis Ladanum.
Stachys betonica.
Atriplex deltoidea.
Rumex conglomeratus.
Ulmus montana.
Fagus sylvatica.
Potamogeton perfoliatus.
—— heterophyllus.
Eriocaulon septangulare.
Juncus compressus.
Scirpus fluitans.
Cistopteris fragilis.

Fifty-one species also are not recorded from the outer West Highlands, subprovince 33, including Islay, Mull, Skye, &c.

Anemone nemorosa.
Corydalis claviculata.
Sisymbrium thalianum.
Stellaria graminea.
Cerastium alpinum.
Rubus cæsius.
—— cordifolius.
—— umbrosus, *Arrh.*
—— corylifolius.
Rosa tomentosa.

Epilobium anagallidifolium.
—— alsinifolium.
Circæa alpina.
Saxifraga nivalis.
Sanicula europæa.
Apium graveolens.
Ægopodium podograria.
Galium uliginosum.
Hieracium anglicum.
—— iricum.
Carduus nutans.
Vaccinium vitis-idæa.
—— oxycoccus.
Pyrola secunda.
Fraxinus excelsior.
Veronica scutellata.
—— montana.
Galeopsis ladanum.
Stachys betonica.
Atriplex deltoidea.
Rumex conglomeratus.
Euphorbia peplus.
Ulmus montana.
Fagus sylvatica.
Habenaria chlorantha.
Malaxis paludosa.
Juncus compressus.
—— Gerardi.
—— trifidus.
—— triglumis.
Scirpus lacustris.
—— maritimus.
Carex pilulifera.
Avena pratensis.
Poa nemoralis.
Cistopteris fragilis.
Polystichum lonchitis.
—— aculeatum.
Botrychium lunaria.
Lycopodium alpinum.
Pilularia globulifera.

Besides these two lists 120 species from the Hebrides have never been recorded; while 51 species are recorded from the Hebrides which either do not grow in Skye, or, what is much more probable, were overlooked by the author.

Ribes spicatum, Robson, with densely tomentose leaves, especially on the under surface, was discovered first at Uig, and then in large quantities on the cliffs about Dunvegan Head.

Any botanist with a month to spare would be yet amply repaid in further investigating the flora of this island; the more southern portion called the Sleat was hardly examined, and as it is quite different in its geological formation to the rest of Skye, a large number of species will in all probability be found, as yet unknown to the subprovince.

On the Discovery of Buxbaumia aphylla *near London.* *By* M. A. Lawson, *Professor of Botany in the University of Oxford.*

One day towards the end of April last during an excursion to Virginia Water, the author found on the freshly upturned clearings of a ditch, skirting a pine-wood, six specimens of this curious and interesting little moss. Although recorded from many parts of Scotland, it is but the third time it has been found in England. The first to find it in Great Britain was the late Sir William Hooker, who, when he was almost a boy, discovered it on some stumps of trees while shooting in Sprowston Woods in the neighbourhood of Norwich. Justly elated with this piece of good fortune, he gave himself up (he had thought little of botany before) to the study of plants. What, then, do we owe to this insignificant little moss?

The third locality was Sawley Moor in Yorkshire, and both here and at Sprowston it has been found only once.

On Type Variation and Polymorphism in their relation to Mr. Darwin's Theory of the Origin of Species. By Benjamin T. Lowne.

The author considered the absence of any great departure from type directly opposed to any considerable modification having taken place by selection, that the simple absence of connecting links between different groups was in itself very difficult to explain, although perhaps the imperfection of geological record might fairly be urged in explanation, yet that the difficulty is vastly increased when we remember that if such forms ever existed, they have left no diverging descendants. If such a complex organ as the eye had been formed by natural selection, its identity of type and structure throughout the Vertebrata is inexplicable; whilst such forms as *Talpa*, *Spalax*, and *Chrysochlorus* do not represent connecting links in

the gradual development of the visual organ, since it must have been perfected long before such creatures could have come into existence under the genetic theory.

Between the conflicting evidence afforded by such facts, which the author designated "rigidity of type," and the plasticity or variability of form shown to exist by Mr. Darwin, in both the animal and vegetable kingdoms, he thought there was but one safe theory, *i. e.* "that animals and plants varied, and are modified by natural selection *within certain limits.*"

The author endeavoured to show that variability was a character inherent in certain organisms capable, like other characters, of being increased or diminished by selection in a number of successive generations. The slight amount of variation known to exist in nature compared to that of domestic and cultivated forms, was noticed at length, together with the amount and nature of variation in polymorphic or protean genera. Mr. Lowne thought it highly probable that accidental characters neither of use or the contrary to the individual, became fixed by isolation, especially amongst insects, where a single male is often capable of impregnating a whole isolated colony of females.

The nature of the variation in *Eucalyptus* was stated to be quite unlike that of most variable forms, the leaves and flowers, according to the author's observations, being very variable in each species in characters usually most constant in other groups, so as to produce the greatest confusion in herbariums and scientific descriptions, although he admitted that further evidence was wanted upon the subject.

Divergence of character under competition was next discussed and stated to be extremely exceptional; the gradual extinction of thirty species of Elephant and their reduction to two was noted as an example quite at variance with the theory.

Lastly, the author stated that he believed Mr. Darwin's theory was a most important one, and thoroughly proved within certain limits; that the establishment of the existence of such limits was his aim, not the contradiction of a single fact advanced by that great observer; and he concluded by saying although it will perhaps always be impossible to draw a line between the constancy of type and the variation or modification of species, yet that future observers might assign a limit practically sufficiently near for the right interpretation of the Cosmos of Organic Nature.

On the Proboscis of Ommatoplea. *By* W. C. McIntosh, *M.D., F.L.S.*

In this paper attention was drawn to the structural differences between the Ommatoplean and Borlasian proboscides; and the views of MM. de Quatrefages, Max Schultze, Van Beneden, Claparède, and Keferstein, in regard to the structure of the Stylet-Region in Ommatoplea, commented on, with the aid of drawings.

On the Boring of certain Annelids. *By* W. C. McIntosh, *M.D., F.L.S.*

This paper was brought forward with a view to show that the chemical or acid theory, advanced last year by Mr. Lankester, cannot be applied to the boring of Annelids, any more than it has been found to explain all the facts connected with the perforations of Echinoderms, Gephyrea, Mollusca, Bryozoa, and Sponges, and to maintain the statement of the author (which Mr. Lankester had doubted), viz. that *Leucodore ciliatus* bores in aluminous shale.

Instead of the boring of the latter species being new, as asserted by Mr. Lankester, it, as well as the chemical theory in regard to annelidan borings, was shown to be very old. Moreover the perforations occur in sandstone, as well as in aluminous shale, calcareous rock and shell. The author also described the borings of *Dodecaceria concharum* (a species very frequently associated with the former), *Sabella saxicava, Sipunculus,* &c.

On the occurrence of Lastrea rigida *in North Wales.* *By* George Maw, *F.L.S., F.G.S.*

With the exception of a single specimen found in the neighbourhood of Bath,

supposed to have been introduced, and another locality in the county of Louth, where the plant occupies a stone wall, the author pointed out the limited geographical range of the species, considered hitherto to be confined to a small area of the mountain-limestone district bordering on the counties of York, Lancashire, and Westmoreland. Beyond this it had not been observed in the British Isles till its discovery last year near Llangollen by Mr. George R. Jebb, of Ffrith Hall, Wrexham. It occurs abundantly in a recess of the escarpment three and a half miles north of Llangollen, immediately to the south of Craig Arthur, which forms the western extremity of this part of the mountain-limestone range.

Its limited distribution as regards altitude was noticed here as in the Yorkshire habitats. In both districts it appears to be confined to a range of altitude between 1000 to 1100 feet above the sea-level, and also occupies the same position on the mountain limestone, occurring within 200 or 250 feet of its base both in Yorkshire and Denbighshire. The fern is also said to have been found on the Eglwyseg rocks, a little to the east of Llangollen, about four miles from the Craig Arthur habitat.

On the "Muffa" of the Sulphur Springs of Valdieri in Piedmont. By M. Moggridge, *F.G.S.*

Muffa is found in those springs which have a temperature of about 50° Centigrade. It first appears as tender minute filaments, soft and floating, of a greenish-white colour. It soon becomes more substantial, changing to violet, then light-yellow, and finally to pale-green.

It was considered by Allioni to be *Ulva labyrinthiformis*, Linn. In 1837 Fontan describes it as composed of filaments $\frac{1}{400}$ to $\frac{1}{200}$ of a millimetre in diameter, tubular, cylindrical, simple, devoid of septa, containing semiopake globules, collocated when young, separated towards the ends when mature. He named it *Sulphuraria*.

Delponte places it in the genus *Leptothrix*, Kütz, giving it the trivial name *Valderia*.

The microscope reveals spontaneous movements, caused by minute animals, considered by Defilippi to be of the genera *Cryptophagus* and *Comurus*.

The residuum after burning was 28 per cent.

One hundred parts of pure cinder contained—

Oxide of Potassium	15·271	Oxide of Iron and Manganese	24·162
" Sodium	11·637	Chlorine	2·445
" Calcium	7·938	Sulphuric acid	9·232
Magnesia	1·915	Phosphoric acid	4·481
Alumina	9·833	Siliceous acid	13·115

Discovery of Scirpus parvulus *in Ireland. By* A. G. More, *F.L.S.*

The author found *Scirpus parvulus* a few weeks ago growing abundantly in some salt-marsh creeks bordering on the north side of the river Ovoca, where it falls into the sea at Arklow. The station of the plant is peculiar, as it grows quite by itself on the surface of the soft mud which is overflowed at high water, and where no other sea-side plants seem able to secure a footing. The creeks are bordered by a luxuriant vegetation of *Juncus maritimus*, *J. Gerardi*, *Poa maritima*, &c., but the author did not find *Scirpus parvulus* mixed with them; it occurs only towards the deeper water upon the soft mud, which we usually find quite bare of vegetation; and it was from observing the little green tufts in such an unusual situation that he was led to examine them more closely, when the spikes of a *Scirpus* left no doubt as to what it was.

Scirpus parvulus is truly subaqueous for a large portion of its existence, and shows some resemblance to *Isoetes* in the structure of its stems, which grow with their lower third buried in the mud, and are cellular and transparent, being composed of four (or rarely five) longitudinal tubes divided at intervals by numerous transverse partitions. Finding among authors considerable differences of opinion as to the presence or absence of sheaths, the existence of leaves, and the duration of the

root, the author has taken some pains in examining many specimens, and thinks he may say that nearly all the stems are sheathed at the base by a very thin close-pressed transparent membrane, which is always to be seen surrounding the rising stems, and which the author is disposed to think may have fallen or decayed away in the few cases where he did not see it on the adult stem. Further, he inferred that these sheaths should be considered to represent the leaves, and that the so-called leaves are only barren stems; and certainly these outer stems do not sheathe the inner, as occurs, for instance, in the fronds of *Isoetes*, but each rises independently from the side of its neighbour. The little tufts throw out numerous white fibrous roots, and also very slender filiform runners ending in minute tubers, which he believes are hybernacula, and serve to propagate the plant*. Hence, even if the tufts die away annually, the tubers will still remain and the root be perennial.

This little plant seems widely scattered along the coasts of Europe, from the Baltic and German Ocean in the north to the Adriatic in the south, occurring especially in many localities on the western coast of France, but is everywhere a rare and local species, and is said to be more abundant in some seasons than at others. In England it has not been gathered since 1837, when the Rev. G. E. Smith collected specimens near Lymington in Hants, so that its discovery at Arklow may almost claim to restore to the British flora a very curious and interesting species. Fresh specimens of *Scirpus parvulus* were exhibited to the Section.

On the Difficulties of Darwinism. By the Rev. F. O. Morris.

Mr. Darwin's first work on 'Selection by Species' is alone referred to in this paper. The old belief was that a species, subject indeed to variety, was a separate kind of itself, and had so continued from the original creation. The new theory, viz. that so-called species are not descendants of originals of the same kind, but the offspring and offshoots in the lapse of vast ages of a more limited number of forms by process of natural selection, leads to the startling result that all species, genera, orders, classes had one common source of being in some one first parent. One cause imagined to operate in this subdivision of species is an internal impulse acting on accidental advantages and compelling a continued change in the form. It is quite true that energies of the mind called forth by exigencies of the body do produce changes and improvements in the body for a time, but not permanently, not beyond the individual concerned—as in the case of the blind, whose other senses are quickened to make up for the loss of sight. Examples were given of the adaptation to circumstances in their case, and the capacity to improve the condition of the individual corporeally. But these powers only serve the occasion. They are not permanent or hereditary.

Again, if by the retention of accidental advantages, such as superior strength, new species are formed, how can this apply to insects and birds only distinguishable by colour, and with few gradations in relative strength? If the strongest creatures were intended to prevail, why have the Dinotherium and Plesiosaurus and Mammoth perished? If insects with elaborate organs live but a few days or weeks, how could those organs have been produced by process of natural selection? If there was only one species at first, whence and why that diversity of plants suitable for the food of various species? Why, if natural selection acts for the good of the creature, are so many transmutations of a downward tendency? Is not every variety of pigeon a pigeon still, and so of the horse, ox, dog? May not each species be at once seen in the variety? Was the primordial form both male and female? How came it to require improvement in its normal condition? Was it of animal or vegetable nature? Why do lower forms exist still? Can a strong or handsome man secure the transmission of his strength or beauty, wish as he may? Yet man is the highest creature, and he, if any, might desire to benefit his offspring by perpetuating natural advantages. And why should not this supposed power of natural selection avail a man to get rid of disadvantages, as in the case of a blind person, or otherwise deficient? Why the retrogressions and degradations seen amongst mankind? Some such disadvantages are temporarily hereditary, and no volition can remove them. If the power of selection can perpetuate change of form, why

* It may be added that the author could not discover any ripe seed early in October.

cannot it alter the ordinary condition? Dædalus could not throw out wings with a wish. What power would favoured individuals of any species have over atmospheric and other causes that sweep off the rest, leaving those born earlier or later to survive? How do both parents obtain the same improved condition at once? Do the creatures trouble themselves about their offspring?

With regard to the reversion of varieties to their original forms, which Mr. Darwin doubts, is not the pansy an example of the difficulty of keeping varieties distinct? and so with other flowers which have a tendency to revert to their inferior originals.

After touching on various other difficulties, the questions were put,—Whence do birds derive the migratory impulse?

Again, the great object of numberless creatures is the mere perpetuating of their kind, which is no sooner attained in the last and briefest stage of existence of the majority of insects than they die, leaving their progeny to the same course of long existence in the egg, caterpillar, and chrysalis state, and then for a similar destruction to follow immediately on the deposit of their eggs. There is no time for the supposed exercise of natural selection. They are born, lay their eggs, and die, having been dormant in the egg and chrysalis states. They can only energize in the imperfect caterpillar stage. And what thought can the caterpillar take for improving its condition in the imago state? Only the perfect insect could desire a change, but the perfect insect has no wants to supply, and therefore can wish for no change.

Why do no characteristics of the earliest forms sometimes show themselves in animals of the present day?

The author believes that the multiplication of races is limited, not by their warring against each other, but by laws of nature inscrutable to us.

On the Zoological Aspect of Game Laws. *By* Professor ALFRED NEWTON, *M.A., F.L.S.*

The term "Game Laws" seems to express most conveniently all those regulations which have been adopted in various countries to control the relation of man to wild animals, and in this sense the phrase is here used.

The subject of the destruction of animals is rarely discussed in the public prints without great exaggeration, and the most one-sided views of the question are constantly presented. Some advantage, however, has arisen from the attention of the public having been called to the question. The most effectual protection to animals is that afforded by public opinion. A most striking instance of its influence is that presented by the fox. Not much more than a century ago, the British farmer was only induced to permit the galloping of horses and hounds over his corn by the reflection that they were doing him a great service in ridding him of a pestilent marauder, and he would hear with grim satisfaction that the scourge of his wife's hen-roost had been run into, or he would willingly at a vestry-meeting pass the churchwardens' accounts giving rewards for the destruction of a vixen and her cubs among other so-called vermin. Now-a-days the British farmer is generally in the first flight of the horsemen, and the fox has no friend so staunch. A similar change in public opinion with regard to other wild animals is most desirable. The public should feel that they have an interest in the protection of wild animals, especially during the season of reproduction. The decrease of these animals, however, is often attributed to secondary causes, and not to direct slaughter. Man had no great spite against the Bustard or the Great Copper Butterfly, but both have been extirpated within living memory—the latter probably owing to the drainage of the fens, though the precise mode in which its extinction has been accomplished is not exactly known. Both, however, might possibly have been preserved by a little judicious care. At any rate, if the progress of civilization unconsciously demands some few victims, we should abstain from wilfully adding to their number. Mr. Tristram contended, at the last Meeting of the Association, that birds of prey were the sanitary police of nature, and that if they had existed in their original strength they would have "stamped out" the grouse disease, just as the Orders in Council "stamped out" the cattle-plague.

Hawks, by preference, make sickly birds their quarry. In Norfolk there is no moor game, and therefore no grouse disease. But the game-preservers of the county believe that their stock of pheasants and partridges is materially increased by the destruction of everything which they are pleased to call vermin. Now the abundance of game has but little to do with the scarcity of birds of prey, and in some foreign countries the existence of numerous birds of prey is a pledge of the plentifulness of game. Owls are undoubtedly the game-preserver's best friends. His most serious foe is the rat, and owls consume more rats and mice than any other description of food, an assertion proved by the investigations of Dr. Altum (Journ. für Orn. 1863, pp. 41–46, 1864, pp. 429–434; Ber. xiv. Versamml. D. O. G. pp. 30–34, and Zool. Gart. 1867, pp. 262–266) and others. So with regard to polecats, stoats, and weasels. With reference to sea-fowl, a certain amount of sentiment may be confessed. No animals are so cruelly persecuted. At the breeding-season they come to our shores, throwing aside their wary and suspicious habits, and sometimes settling far inland. No one has ever complained of them as injurious, as raising the price of herrings, sprats, or oysters. Yet excursion trains convey the "sportsmen" of London and Lancashire to the Isle of Wight and Flamborough Head, for the purpose of destroying these harmless birds. Each bird shot was a parent, and its young were thus exposed to death from hunger. Could men blaze away hour after hour at those wretched birds without being morally the worse for it? We thank God that we are not as Spaniards, gloating over the brutality of bull-fights, whilst we forget the agony inflicted on thousands of innocent birds on our coasts to which that of a dozen horses and bulls in a ring is as nothing. The enormous demand for the feathers of sea-fowl by the modern fashion of ladies' hat plumes has added to this cruel destruction.

The legislative appointment of a "close time," to be proclaimed by the local authorities, during which the mere carrying of a gun should be an offence, is absolutely necessary. This plan has been adopted in several countries, including some of the most democratic, as shown by the Game Laws of Switzerland, Norway, the United States of America, and several British colonies. The question is one wholly unconnected with party politics, and it should be so regarded. If the present state of things continues much longer, far greater changes will take place with regard to the fauna of this country than most persons suspect, and they will be changes for which the zoologists of future generations will not thank us.

On a new Eschara *from Cornwall. By* C. W. Peach, *A.L.S.*

Eschara verrucosa, Peach.—In 1848 the author obtained this Coral from Lantivet Bay near Fowey, and at the time gave it a slight examination only, as he left that part soon after it was packed up and remained so until a few days ago, when it turned up, and on careful examination proves new to the British list.

Polyzoary buff-coloured, dichotomously branched; branches cylindrical and rough. Cells deeply immersed; older ones very much roughened all round by knob-like pitted eminences, at times almost covering the cells; the mouth moderately large, rounded above this part in the young, with five perforations as if spines had been broken off. Lower part of mouth straight. On one side of each cell, a little below the lower lip, not always on the same side, is a raised avicularium, perforated on the top with a triangular opening, from which springs a gold-coloured bayonet-shaped vibraculum. The young cells are raised and smooth. As it differs from all the branched British Corals known to the author, he has named it *Eschara verrucosa*, from its rough appearance.

Unfortunately it was broken from its attachment; it was, however, quite fresh. The fragment is $\frac{3}{4}$ inch in height, spread of branches about the same, breadth of stem and branches about one-tenth of an inch.

On the Structural Peculiarities of certain Sapindaceous Plants. By Professor Radlkofer.

The ordinary mode of growth of the stem of dicotyledonous plants is by the continual addition of a cylindrical layer of tissue between the bark and wood, a

new stratum of wood being formed by the cambium outside the old wood, and a new stratum of bark on the inside of the full-grown bark. From this ordinary mode there are occasional deviations. In a former paper I directed the attention of botanists to one exception in the case of Menispermaceæ, where at the end of every three or four years the cambium becomes inactive, and a new one is formed outside of the bast.

Having been for some time engaged in the systematic study of the difficult tribe of Sapindaceæ (the "crux Botanicorum"), I have had abundant opportunities of examining the structural peculiarities of this most interesting tribe of plants, the small branches of herbarium specimens exhibiting the same peculiarities which strike observers with so much surprise in large trunks.

I do not propose at present to explain in detail the development of these irregularities in Sapindaceæ, nor to trace their relations to other families, such as Bignoniaceæ, Malpighiaceæ, &c. My object is to state as briefly as possible the most remarkable modifications of wood structure which I have observed. To enter into details, it would be necessary to have the specimens themselves at hand, but it would not have been possible to bring with me the numerous materials which I have had from the Berlin, Vienna, Copenhagen, St. Petersburgh, and other Herbaria.

The two genera in which I have observed anomalous stem-structure are *Serjania* and *Paullinia*, and in both normal stems also occur. In *Paullinia* I have noticed only one type of irregularity with some slight modifications, and as the same type with nearly the same modifications is found in *Serjania*, I shall confine my remarks to the latter genus.

If we examine transverse sections of young branches (one to three years old) of *Serjania*, we seldom find a circular wood. In most species it is angular, trigonal or pentagonal. In some species the angles are very prominent, so that the wood is deeply furrowed, or, what is yet more striking, the angles become detached from the centre, so that the wood is compound.

Different kinds of compound wood occur in different species. There may be as many peripheral detached parts as there are angles, or there may be fewer, sometimes only one; or again, there may be more, often as many as eight or ten nearly touching one another, so as to form a ring round the central wood. The peripheral parts may be either cylindrical with the stem indented, or the parts may be flattened in different degrees, and in the latter case the stem is smooth, without any indication of the internal irregularity.

Besides all these modes of irregularity, there is yet another which cannot be brought into connexion with them, and which I have not seen anywhere described. It consists in the wood being split by radial divisions into five nearly equal portions. This I call divided wood.

We can thus distinguish in different species of *Serjania*, *round* wood, *polygonal* wood, *furrowed* wood, *compound* wood, with as many or more parts than there are angles, and finally *divided* wood. Now I have found that in each species of *Serjania* and *Paullinia* the form of stem is constant, provided the observation be made in the right place, namely about the middle of the branch, and not at the lower part near its origin, where the different parts of the compound and divided wood are commonly united into one single wood. The section must also not be made immediately below a leaf; for there the number of peripheral parts is frequently diminished by their union with the central wood. The neglect of these precautions has led to the belief by former observers that there is no constancy in each species. There is, however, certainly such constancy, and as it is now for the first time pointed out, I desire particularly to direct attention to it, as well as to the further fact, that the structure of the wood corresponds closely with the specific characters derived from the flower and fruit, so that groups of species formed from the wood-structure will be nearly identical with those based on flower and fruit-structure, and may therefore be considered as quite natural.

It would lead me too far were I to attempt to lay before you an abstract of these natural groups thus formed. They will appear in a general work which I am publishing on Sapindaceæ, where they will be accompanied by the necessary plates. I may mention here, that the grouping of the species of *Paullinia* and *Serjania*

by the form of the leaves, the only method hitherto tried, is in no way natural, and is therefore of no value. By the careful study of the stem-structure I hope that it will in future not be more difficult to determine the species of these two now so very confused genera, than those of *Saxifraga* or any other very large genus. It is to be regretted that the earlier botanists have never in their descriptions or figures given any particulars of the structure of the stem. Had they done so, many mistakes would have been avoided. For example, it would never have been possible to confound the *Serjania triternata* of Willdenow with the *Paullinia curassavica* of Jacquin, or the *Serjania lupulina* of Schumacher, as has so often been done. The only instance in which I have met with a recognizable figure of stem-structure in the copious literature of Sapindaceæ is in Pavon's figure of his *Semarillaria alata*, the *Paullinia alata* of Don.

There is yet another structural peculiarity which will probably afford a good character for distinguishing the species of *Serjania*, which I find nowhere noticed. It is the epidermis of the leaves, which in some species is formed of what is called "Collenchyma," like the epidermis of the seeds of *Linum*. My observations on this point being still in progress, I content myself here with the mere notice of the fact.

On the Extinction of the Great Bustard in Norfolk and Suffolk. *By* H. Stevenson, *F.L.S.*

After referring to some very early allusions to the existence of the bustard in this country, and to the gradual diminution and extinction of the species in the different English counties, the author said that Norfolk was the last county to reckon the bustard amongst its resident species. The two latest "droves" had their headquarters in the open country round Swaffham and in that near Thetford. The Swaffham drove formerly consisted of twenty-seven birds, but the number subsequently decreased to seventeen, sixteen, and eleven, and finally dwindled down to five and two. All accounts agreed in stating that the last remaining birds were hens. One great cause of the extinction of the bird was the introduction of improved agricultural implements, which destroyed the eggs. The precise time of extinction could not be determined with accuracy. The last known specimens were seen about the year 1838; but it had been stated that some of the birds had lingered on till 1843 or 1845. The other drove, near Thetford, consisted of thirty or forty birds; but the number gradually declined to twenty-four, eighteen, fifteen, nine, seven, six, five, and two, the last survivors being hens only. Some persons suppose that the bird could be taken by dogs, but this was not confirmed by the testimony of trustworthy eye-witnesses. The author referred to the local distribution of the bustard in the county, and to the appearance of occasional immigrants from the Continent.

On the Tusks of the Walrus. *By* Dr. Otto Torrell.

Notes on the Flora and Fauna of the Seychelle group of Islands. *By* Professor E. Perceval Wright, *M.D.*

Anatomy and Physiology.

On certain Effects of Alcohol on the Pulse. *By* Francis E. Anstie, *M.D.*

The author described certain effects of alcohol upon the pulse which he had observed with the aid of Marey's sphygmograph. This instrument, which writes the form of the pulse-waves upon paper or smoked glass, has recently been rendered more exact in its indications by the application of a principle originated by Dr. Burdon-Sanderson, by which the precise weight with which the tactile spring

presses upon the pulsating artery may be calculated in grammes. The subject of the author's researches was the febrile pulse of typhus and other fevers, and of pneumonia and some other acute inflammations. In all these diseases the arterial tension is lowered throughout the period of fevers and elevated temperature. The pulse-curve always becomes dicrotous: instead of the wave being slightly *three*-pointed, it presents only *two* elevations with a gap or notch between them, which is more or less deep in direct ratio with the violence of the febrile symptoms and the lowering of arterial tension. When alcohol acts favourably (as indicated by the decline of temperature, *slowing* of the pulse, and cessation of delirium or stupor), it is universally found that the pulse-curve becomes less dicrotous [elevated tension]; on the contrary, when alcohol confuses the intellect and aggravates the feverishness, the pulse-trace is invariably rendered more markedly dicrotous, the notch being deepened [lowered tension]. It is therefore of first-rate importance, when we are in doubt as to the propriety of administering alcohol in fevers or inflammation, to give an experimental dose, taking comparative sphygmographic traces before, and 15 minutes after the administration. If arterial tension has been increased, the alcohol may be confidently continued; if it has been diminished, the alcohol must be at once diminished or altogether discontinued, for the experimental dose has acted as a depressant.

The above rules are chiefly applicable to the cases in which the pulse is of a certain volume, and its sphygmographic curves are large. But there are many cases in which the pulse is small, although it presents all the true dicrotism of the febrile pulse. It is then of great consequence to ascertain whether the smallness of the pulse is due to impairment of the heart-power; and the new arrangement for the graduation of spring-pressure enables us to do this with great ease. We discover, namely, the exact amount of spring-pressure under which the pulse-curves are produced of the maximum size. If the pressure required to develope the maximum curve be as much as 200 or 250 grammes, this indicates a good amount of heart-power; if, on the contrary, the maximum curve be obtained with a pressure of only 100 to 120 grammes, we may be sure the heart is decidedly feeble; and it is preeminently a case for the administration of alcohol.

Such are the empirical facts which the author has established by an experience of many hundred cases of fever and inflammation. The physiological explanation of them is by no means so certain. Is the elevation of arterial tension which is certainly produced by a dose of alcohol which (under the circumstances) acts as a reviving stimulant, while it simultaneously reduces the feverishness, brought about by a stimulation of the vaso-motor nerves, causing contraction of the arterioles? Or is it produced by a stimulation of the vagus, whose central power over the heart it increases? Or does it act by a general stimulation of the spinal cardiac centres, which also might antagonize the excessive action of the heart? The author is of opinion that stimulation of the *sympathetic* is at any rate the earliest, and probably throughout the chief, part of the effect of alcohol on the circulation. On the other hand, Professor Behier of Paris (who has also observed with the sphygmograph the remarkable effects of alcohol upon the pulse in acute disease), while admitting the extreme complexity of the problem, is more inclined to believe that stimulation of the central power of the vagus has the principal share in the tonic and slowing effects of alcohol upon the circulation.

On the Generation of White Blood-corpuscles. By Dr. Behier.

On Electrolysis in the Mouth.
By W. Kencely Bridgman, *L.D.S., R.C.S. Lond.*

About six years ago the author obtained the Tomes Gold Medal of the Odontological Society of Great Britain for a prize essay on the Pathology of Dental Caries. The theory on which the essay was founded was Electrolysis, and was accompanied by various preparations demonstrating the effects of electric action upon organic matter, together with the electro-decalcification of enamel and dentine, and the transference of the lime-salts to the negative electrode or cathode. The

illustrations were accepted as highly satisfactory; but the theory itself, being somewhat novel in relation to physiology, has remained altogether unappreciated by the profession. The object of the present paper, therefore, was to bring forward a case of similar action occurring *in situ*, in connexion with the teeth, which should afford a more decisive illustration of the fact of electrolysis having taken place in the mouth under corresponding circumstances, and the elements of the tooth substance having become so disposed of. The proof tendered was as follows:—On removing a ligature of silk twist which had been placed upon some upper front teeth, a deep groove was found to have been formed in the enamel along its entire course; at the same time the fibres of the silk had become matted together with an incrustation of crystals of lime, showing an unmistakeable case of electrolytic transfer, in which the lime-salts of enamel had been dissolved and recrystallized upon the silk.

In the theory of dental decay by electrolysis, particles of charcoal arising from eremacausis or slow combustion, which like the silk are electro-negative, are represented as playing the same part with the enamel and dentine as the silk had done in the present instance; but it was also stated that pressure, rendering the part non-homogeneous, was equally capable of producing a negative centre from which local galvanic action would arise. The characters peculiar to decayed dentine are its entire decalcification and absence of lime solution, but having in its stead an abundance of free acid—two features which all other theories are incapable of accounting for. If a piece of ivory be placed for a few days in water under the electrodes of a small sustaining battery, the spot beneath and around the anode, or positive electrode, will be found to have become decalcified, softened, and strongly acid, just as these conditions occur in natural decay. In addition to this, the lime will be transferred to the cathode in the same manner as it was to the silk, a fact which affords the only intelligible explanation of the formation of tartar yet offered. Tartar may be thrown down from the saliva as an electro-deposit; it is repelled by the electro-positive crown of the tooth, but adheres to the electro-negative root at its neck. This polar condition of the tooth, illustrated in the different modes of growth between the crown and the root, is referred to as a very important character, and one to be well considered; for all remedial and reparatory measures, to be successful, must be in harmony with such an arrangement.

On the Connexion between Chemical Constitution and Physiological Activity. *By* Dr. A. Crum Brown.

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*Is the Eustachian Tube Open or Shut in Swallowing?** *By* Professor Cleland, *M.D.*

Professor Cleland pointed out that in ordinary circumstances the tube is really open, and not shut as was taught by Mr. Toynbee. In support of this statement he mentioned that he had had the opportunity of seeing the orifice of this tube in a patient with a limited ulcer of the palate, and that he had made this patient swallow with his mouth open, and had the satisfaction of demonstrating to several pupils that the Eustachian orifice was then momentarily closed. He proceeded to take up the anatomical part of the subject, and showed that the disposition of the palatal muscles was in harmony with this observation, and such as to render Mr. Toynbee's theory untenable.

On Flukes from the Indian Elephant. *By* Dr. Cobbold, *F.R.S.*

The object of this communication was to prove (from specimens forwarded by Vet.-Surgeon J. Thacker, through Dr. Cleghorn) that the trematode worms in question were referable to the genus *Fasciola*, constituting a new species, which, as such, had never hitherto been properly described. He proposed to name it after Dr. Jackson of Boston, U.S.; thus *Fasciola Jacksonii*, Cobbold = *Distomum elephantis* of Jackson and Diesing.

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* This paper is published in the Journal of Anatomy and Physiology, November 1868.

On the Relative Weight and Form of the Eye and Colour of the Iris in Vertebrate Animals. By EDWARDS CRISP, *M.D.*

This paper on the relative weight, form, and colour of the eye in the vertebrata was illustrated by drawings and casts of the eye of more than 1000 animals. The eyes of 600 animals, quadrupeds, birds, reptiles, and fishes, filled with plaster of Paris, and coloured by the author after nature, were also exhibited with wax casts of the eye and muscles of the Lion, Elephant, Giraffe, Walrus, and Whale. According to the author, brown was the prevailing colour of the eye in all mammals, birds, and reptiles; whilst in fishes yellow, yellow-brown and whitish-yellow were the most frequent hues. Fishes have proportionately the largest eyes among the *vertebrata*, and among the land-quadrupeds the Giraffe, Horse, Eland, Elk, and Bison have the visual organ of the greatest size. The preparations of the eye were intended to show the great advantage of the use of plaster of Paris in certain anatomical preparations, a method first made known by the author at the Meeting of the Association at Bath in 1864, and at the Zoological Society of London in 1853.

On some Points relating to the Visceral Anatomy of the Thylacinus. *By* EDWARDS CRISP, *M.D.*

The author in this paper on the intestinal canal of the *Thylacinus* (Tasmanian wolf), said he was the first to notice it in 1854. A male and female sent over in spirits had been recently dissected, and in the stomach of the male a marsupial, weighing about two pounds, was found, with the skin nearly entire and many of the bones. The animal has the most remarkable alimentary canal, according to the author, of any animal in existence. It barely exceeds twice the length of the body, and is covered with villi so as to extend the absorbing surface—a beautiful and wise provision in an animal that travels long distances for its food. The duodenum close to the pylorus is thickly studded with slender villi; these become larger, and are more closely packed in the central part of the tube, and extend to about 18 inches from the anal opening. They resemble somewhat the villi in the small intestines of the Rhinoceros and those in the third stomach of the Hippopotamus, as was shown in various drawings to the Section.

On the Intestinal Canal and other Viscera of the Gorilla. *By* EDWARDS CRISP, *M.D.*

The author in this paper compared the visceral anatomy of the Gorilla, Chimpanzee, and Orang with that of Man. The paper was illustrated by numerous drawings, and a model of the viscera of the Gorilla. Two of these apes (Gorillas), a young one and an adult, the author had examined, the last named by permission of the Council of the Royal College of Surgeons. The subjoined were some of his conclusions:—That the thoracic and abdominal viscera of the Gorilla generally differ considerably more from those of Man than the same parts in the Chimpanzee and Orang; and looking to many other brutal characters in this animal the line of demarcation between it and Man is so wide and definite that we may disclaim all relationship with him and his four-handed colleagues. Among the differences pointed out in the visceral anatomy of the Gorilla, were the enormous capacity of the cæcum and large intestines, the peculiar glandular structure of the former, and especially the tripartite division of the liver. Comparisons were made between the length of the intestinal canal of this ape and that of Man, the Orang, Chimpanzee, and many of the lower quadrumana. The intestinal tube of the adult Gorilla measured 34 feet 7 inches in length, that of the young animals (aged about 12 months) 13 feet $9\frac{1}{2}$ inches.

On Vitality as a Mode of Motion. *By* DR. THOMPSON DICKSON.

On the Power of Utterance in respect to its Cerebral Bearings and Causes. *By* R. DUNN.

Viewing the faculty of speech as an instrument of thought and language, as the

minister and interpreter of the thoughts, feelings, and emotions of the mind, the author maintained that, in all cases of loss of speech which are of *cerebral origin*, there is involved either structural change or functional derangement in the nervous apparatus of the intellectual consciousness. The author briefly narrated two illustrative cases out of a number which had come under his observation, one of structural change, and the other of functional derangement, both of striking significance. But the point which he wished especially to impress upon every physiological psychologist was this, viz. that the power of giving utterance to our thoughts and ideas in appropriate language depends upon the due relation being maintained in its integrity between the centres of intellectual action and the encephalic motor centres through which the volitional power is exercised in articulate speech—in other words, between the cerebral hemispheres and the corpora striata. For thoughts and ideas might be moulded for expression in the seat of intellectual action, but the agency of the will or volitional power to give them utterance requires the integrity of the motor centres, through which the volitional impulses operate on speech. The author said a special cerebral organ had been assigned to the faculty of speech, and that the illustrious Gall was the first to locate it in the anterior lobes of the brain. Since his time the subject had undergone much discussion in France, and conflicting evidence had been adduced. He adverted to the hypothesis of Dr. Dax, that the left hemisphere of the brain was *its exclusive seat*, but to which he could not subscribe. The brain is a double organ; the functions of both hemispheres are identical, in harmonious accordance with the doubleness of the organs of sense, as double inlets to knowledge. Professor Broca, who claimed the honour of being the first to discover that the third convolution was the seat of the faculty of articulate speech, was constrained to admit that the function was not *exclusively* exercised on the left side of the brain, although disease there, with hemiplegia of the right side, was almost universally characterized by aphasia. The author, in proof that the right hemisphere exercised the same function in regard to articulate speech as the left, adduced a case in which there was extensive disease in the left hemisphere, on the very site of Broca's organ, and yet during life the faculty of speech was not impaired.

On the Homologies and Notation of the Teeth of Mammalia. *By* W. H. Flower, *F.R.S., F.L.S.*

After some introductory observations, the author stated that the subject which he proposed to bring before the Meeting was an endeavour to ascertain how much of the generally adopted system of classification and notation of the teeth of the Mammalia—a system mainly owing to the researches of Professor Owen, whose labours in this department of anatomy no follower in the same field could fail to recognize gratefully—stands the test of renewed investigations, how much seems doubtful and requires further examination before it can be received into the common stock of scientific knowledge, and how much (if any) is at actual variance with well-ascertained facts.

One of the most important of the generalizations alluded to is the division of the class Mammalia, in regard to the times of formation and the succession of their teeth into two groups—the *Monophyodonts*, or those that generate a single set of teeth, and the *Diphyodonts*, or those that generate two sets of teeth. The Monophyodonts include the orders Monotremata, Edentata, and Cetacea; all the rest of the class being Diphyodonts. The teeth of the former group are more simple and uniform in character, not distinctly divisible into sets to which the terms incisor, canine, premolar, and molar have been applied, and follow no known numerical law. The group is, in fact, equivalent to that to which the term *Homodont* has been applied by some authors. On the other hand, in the mammalian orders with two sets of teeth, these organs are said to acquire fixed individual characters, to receive special denominations, and can be determined from species to species, the animals so characterized being *Heterodonts.*

The author then showed that among the homodonts, the nine-banded Armadillo was certainly a diphyodont, having two complete sets of teeth, and among the heterodonts, many were partially, and probably some completely, monophyodont.

Moreover that almost every intermediate condition between complete diphyodont and simple monophyodont dentition existed, citing especially the Sirenia, Elephants, Rodents, and Marsupials. He then, by the aid of diagrams, showed particularly two modes of transition between monophyodont and diphyodont dentition—one in which the number of teeth changed was reduced to a single one on each side of each jaw, as in Marsupials, and the other in which the first set of teeth, retaining their full number, were reduced to mere functionless rudiments, and even disappearing before birth, as in the case of the seals, especially the great Elephant seal. These observations showed that the terms "monophyodont" and "diphyodont," though useful additions to our language, as means of indicating briefly certain physiological conditions, have not, as applied to the mammalian class, precisely the same significance that their author originally attributed to them.

The classification and special homologies of the teeth of the heterodont mammals was next discussed. Certain generalizations as to the prevailing number of each kind of teeth in different groups of animals were sustained, but deviations were shown from some of the rules laid down, such as that when the premolars fall short of the typical number, the absent ones are from the fore part of the series. The general inference was, that, although in the main the system of notation of the mammalian teeth, proposed by Professor Owen, was a great advance upon any one previously advocated, we must hesitate before adopting it as final and complete in all its details, and need not relax in our endeavour to discover some more certain methods of determination.

On the Anatomy of the Carinaria Mediterranea. *By* Robert Garner, *F.L.S.*

In this paper the author gave the anatomy of a male and female specimen, without any reference to the descriptions of previous observers, as Delle Chiaje, Verany, and others. The cylindrical form of the animal, finned tail, curiously modified molluscan foot, and the viscera excluded, as it were, by hernia, from the body, and covered by the delicate shell, are tolerably well known. The envelope or tegument, though tuberculated or spiny, as well as covered with small and larger granulated opacities, and mottled with brown, is so diaphanous that the stomach and first part of the intestine can be seen through it. A second inner coat is composed of a beautiful network of muscular fibres, but the tail has fascicles only from this coat. The foot or abdominal fin, carried, however, upwards as the animal swims, is neatly reticulate and tinged with rose-colour, and has a little suctorial disk on its posterior edge. The sea-water is admitted into the body of the animal by a pore behind this fin. The animal has a retractile trunk, and tentacles with well-developed eyes. Within the muscular sac, besides the stomach and first part of the intestine, is little else but the buccal apparatus, two salivary glands opening near the commencement of the gullet, the brain and pedal ganglion, and aorta. The ribbon of lingual teeth is pretty simple—a tricuspate broad tooth in the centre, a large hook on each side laterally, and between the two another piece with a long and short point. These teeth dissolve in boiling nitric acid, and consequently are not siliceous. The buccal box itself is ample, with six or seven pairs of extraneous muscles, besides powerful intrinsic ones attached to its cartilaginous basis. The stomach, which immediately succeeds, contained remains of Pteropoda (small conical Cleodoræ), of small Cephalopoda, and portions of the lingual ribbons of its own species; also beautiful discous and other Diatoms. The bulk of the viscera are covered by the shell, which also has attached to it the muscles, with much the same disposition as is seen in a Patella. The intestine entering this nucleus makes many convolutions at the front of the shell, and then opens on the right side under the margin of the shell and mantle. The brain is supra-œsophageal, and is seen to consist of three amalgamated pairs of ganglia. Of course it gives nerves to the eyes and feelers close at hand, the former having large lenses covered by the transparent skin; also to the mouth, and is connected with two little ganglia situated on the buccal box. Four nerves go backwards from the lateral and posterior parts of the brain, two forming a lobed ganglion near the abdominal fin, supplying it and the tail, and two rising towards the viscera, forming a ganglion at the root of the branchiæ. There are also two nervous enlargements near the pylorus, and auditory sacs on the pedal ganglion.

The branchiæ, about twelve-divided, lie across the fore part of the mouth of the shell, attached on the left side, where are the heart and branchial veins; on the right is the branchial artery, receiving a large branch from the renal organ situated above. Higher still in the shell is the liver with its bile-ducts, and above the liver, in the recess of the shell, the testis in the male and the ovary in the female. The duct from each goes downwards; in the male it opens into a sinus of the integument of the right side, where is also seen, at its termination, a little twisted exsertile body, but which sinus does not exist in the female, the opening being higher, close to the vent, where it is also joined by niditamentary organs; one elongated, the other oval, both laminated within, and the latter dark purple without; in microscopic structure these seemed to be composed of small globular bodies. The testis contained globules, probably endosmosed spermatozoa; the ovary, evident ova. The female specimen was a good deal the larger, and the tail more obtuse than in the male.

On the Albuminoid Substances of the Blood-corpuscles.
By Professor HEYNSIUS.

On the Nomenclature of Mammalian Teeth and the Teeth of the Mole.
By E. R. LANKESTER and H. N. MOSELY.

The authors pointed out the arbitrary and misleading nature of the division of teeth into incisors, canines, premolars, and molars, since to these terms might fairly be added sectorial, bicuspid, tricuspid, laniary; secondly, they show that maxillary and premaxillary are the only divisions admitting of homological identification, the maxillary teeth being further divided into an anterior and posterior series in most diphyodonts, by means of the fourth so-called premolar. They pointed out that there is no homology of upper with lower jaw teeth, and that the present rule for their identification is most arbitrary and unscientific. They show that the so-called canine of the mole is a premaxiliary tooth, that animal being thus the only placental mammal with eight premaxillary or incisor teeth. The authors further describe a new tooth in the badger, making its dentition identical with that of the glutton; this tooth belongs to that series of "premolars" which have no milk-predecessors as described by Mr. Flower recently in the dog and pig, and very rapidly drops out of the jaw.

Notes on the Homologies and Comparative Anatomy of the Atlas and Axis.
By ALEXANDER MACALISTER, *L.R.C.S.I.*

It seems to be a principle in morphology that the greater the amount of specialization of function manifested by any organ, the further does the structure so specialized depart from the form of the primordial type to which it belongs. This principle is particularly exemplified in the case of the two upper cervical vertebræ, the atlas, and the axis, as on account of the special varieties of motion of this region it is in some instances difficult to assign to the parts of these bones their exact positions as serial homologues of the processes in other vertebral segments. We owe much of our knowledge of the relations of these bones to Owen, Rathke, Cleland, and Robin; but a few points yet require to be wrought out with regard to them, so as to enable us to understand more clearly the homologies of their several portions. In order to present a more complete series of relationships between these bones and the ordinary cervical vertebræ, the points to be considered are the following:—(1) the nature and homologies of the body, of the axis, and of the odontoid process; (2) the nature of the preodontoid half-arch of the atlas; (3) the serial homologies of the transverse atlantal ligament and of the occipito-axial or check ligament; (4) the third occipital condyle of Meckel and Halbertsma; (5) the articular processes of the atlas and axis; and (6) the transverse processes of the cervical vertebræ in general, and of these two in particular.

These may be briefly summarized thus :—

(1) The odontoid process is the body of the atlas; a considerable amount of evidence on this point is contained in the original paper.

(2) The preodontoid half-arch of the atlas is considered by Koster as a hæmal arch, by Owen as a hypapophysis; but in the author's paper reasons are given for considering it as an ossified anterior conjugal ligament, like the middle slip of the stellate thoracic ligament.

(3) The transverse ligament of the check-ligaments are serial with the conjugal ligament of the ribs.

(4) The third occipital condyle is homologous with the central part of the ornithic and reptilian condyle.

And lastly, the articular surfaces of the atlas and occipital bone are structurally double, the anterior part being in series with Luschka's *Halswirbel*, the posterior part being probably related to the true oblique process.

On the Transmission of Light through Animal Bodies. *By* Dr. Richardson, *M.A., F.R.S.*

The author exhibited a lamp which he had constructed for transmitting light through the structures of the animal body. He believed the first idea that such transmission could be effected was given in Priestley's work on Electricity. That great experimentalist, the Shakspeare of physical science, had observed, on passing a discharge of a Leyden battery through his finger, that the structure seemed to present luminosity, but the operation was extremely painful. The author had repeated this experiment with similar results. Of late years research had been made with the microscope in the transparent web of the foot of the frog; and last year Dr. M'Intosh had shown that young trout could be used experimentally, they being sufficiently transparent for the investigation of the action of various poisonous substances on their internal organs. The suggestion of Dr. M'Intosh had been acted upon by the author, and the motion of the heart and of the respiration had been observed by direct ocular demonstration while those organs were under the influences of various bodies belonging to the ethyl and methyl series. This research had led the author to extend the principle further; and he had now advanced so far that he was enabled to transmit light through various tissues of the bodies of large animals. He had thought it was best to begin by testing each tissue separately; and this investigation had been carried out on nearly all the structures of the body which admit of being individually examined. The structure the most diaphanous was the skin; after that, and singularly enough, bone; then thick membranes; next, thin superficial muscles, lung tissue, fat, and the dense tissues of the liver and the kidney. Various lights had been tried, viz. the electric, the oxyhydrogen, the lime-light, and the magnesium. For all practical purposes, the magnesium light was the best: it was the most convenient to use, and the light had the advantage of penetrating deeply. In the lantern which the author exhibited the light was also unattended with heat at the point of observation, so that the hand could be put in at the brightest illuminating point. The lamp was made by Solomon, of Red Lion Square. The additions consisted in a tubular arrangement and a sliding groove. The structure to be examined was placed in the groove inclosed between two disks of perforated wood, and the object was surveyed from the further end of the tube. In illustration, a thick piece of bone (the flat rib of an ox) was placed in the lantern, and light was distinctly transmitted through it. "It was," said the author, "important to speak with care as to the extent to which this lantern could be used practically." He did not consider it perfect, but thought it promised results of the greatest interest and value. In the first place, it might be used for a variety of physiological purposes. Animals whose tissues were thin, such as fish, could be placed in the lantern, and the condition of their circulation and respiration could be carefully studied under the action of various agents. In the human subject, especially in the young, having fragile tissues, the thinner parts of the body could be distinctly rendered transparent; and in a child the bones, under a somewhat subdued light, could be seen

in the arm and wrist. A fracture in a bone could, in fact, be easily made out, or growth from bone in these parts. In a very thin young subject, the movements and outline of the heart could also be faintly seen in the chest; but the light he had as yet employed had not been sufficiently powerful to render this demonstration all he could desire. It would be possible, lastly, to see through some diseased structure, so as to ascertain whether, within a cavity, there was a fluid or a solid body. The author concluded by stating that his object had been rather to mark the origin of a new and progressive step than to explain a perfect instrument, or record an extended series of successful results.

On Effects of Extreme Cold on Organic Function.
By Dr. Richardson, *F.R.S.*

The author passed in brief review his experiments performed at Dundee in relation to the effects of feezing the centres of the nervous system. He showed that in the lower classes of animals, such as frogs, the nervous centres can be frozen for long periods of time, with recovery after entire unconsciousness and apparent death. The points added on this occasion were in continuation of this line of research. The author first dwelt on the question whether frozen animals (such as frogs) respire during insensibility, and explained that they did not. In proof of this he said that animals so treated could be placed without harm in gases which would not support life, such as nitrogen and hydrogen, and could be recovered at the precise moment of solution from the frozen state when respiration was recommencing. He had placed animals in this way in hydrogen, nitrogen, and carbonic acid. In other experiments, when the animal was frozen, it was immersed in ether, and allowed to lie under the fluid until, by the rising of bubbles of air, indications of returning life were gained; then, taken out, the animal would recover. The gradual return of heat was thus a pure restorative, and the facts helped to explain many accounts as to restoration after freezing, which up to this time had been stated as strongly on one side as they were doubted on the other. The second point considered had relation to the effects on the circulation of freezing the brain. The author here showed that in warm-blooded animals the effect of reducing the temperature of the brain was to produce a gradual slowness of the circulation, and, when the freezing was carried to the lower part or base of the brain, to produce the condition of heart and pulse known as intermittency, followed, if the operation were continued, by the entire cessation of the heart's movement. This was a point of great practical moment as indicating the influence of the brain on the heart. Whenever the brain was reduced in physical power, as from intense mental fatigue, or shock, or anxiety, irregular action (intermittency of the heart) was almost the necessary result. Most people were conscious of this, and often thought with great alarm that they were suffering from disease of the heart, when in fact they were merely labouring under temporary exhaustion of the brain. The third point went to show that under the influence of extreme cold on the nervous centres (the brain and spinal cord) the extreme effect of such active poisons as strychnine could for a time be entirely suspended. This raised a hope that in such diseases as tetanus, a new and successful mode of treatment might be gradually evolved. The fourth point had relation to the influence of extreme cold in preventing and even in removing the rigidity of death. Because the body after death cools, the inference had been drawn that the rigidity of death was due to the process of cooling. This was the exact reverse of the fact. The rigidity of death was quickened by heat, and prevented by cold, probably for an illimitable period of time, the cold being sustained. Further, by taking an animal already rigid, freezing it, and thawing, the first rigidity could be removed and the body become flaccid. The last point touched upon related to the effect of freezing and rapidly thawing the skin of certain regions of the body. It was shown that birds treated in this manner presented the extremest irregularity of movement, and other signs of nervous disturbance. Thus by freezing and rapidly thawing the skin on the side of the neck of a pigeon, the bird for a time walked sideways in the opposite direction. The author designated this effect as peripheral nervous shock.

On the Pectorales Muscles. *By* Professor G. Rolleston, *M.D., F.R.S.*

On the Physiology of Pain. *By* Professor G. Rolleston, *M.D., F.R.S.*

Additional Researches on the Asymmetry of the Pleuronectidæ. *By* Professor Traquair.

On the Seat of the Faculty of Articulate Languages. *By* Professor Paul Broca.

The Physiology of Language. *By* Dr. Hughlings Jackson.

On sixteen Eskimo Crania. *By* Professor George Rolleston, *M.D., F.R.S.*

Remarks on Language and Mythology as Departments of Biological Science. *By* Edward B. Tylor.

The treatment of accounts of the civilization of tribes of man as details of local geography is connected with a popular notion that these topics are finally disposed of by descriptive treatment; and this notion, in the writer's opinion, is prevalent enough to be a serious obstacle to knowledge. Thus it is far from being a trivial matter of classification that details of human culture should come under discussion as topics of biology, where, if they have any claim to attention, they must be treated as facts to be classified and referred to uniform and consistent laws. To show that the phenomena of civilization, in spite of their extreme difficulty and complexity, are amenable to such treatment as would be applicable to other biological investigations in which law and order are to be sought for throughout masses of multifarious details, was the object of the present paper. Certain special points of culture taken from language and mythology, were brought forward to show how the notion of arbitrary causeless spontaneity in human action disappears when phenomena are classified in their proper groups. In examining the different languages of mankind abundant traces are found of the art of counting by word-numbers having grown up from that primitive plan of counting on the fingers still so familiar to mankind. Again, as savages have reckoned on their fingers and toes, it appears to have struck them that their words for finger, hand, foot, &c. might be used to express numbers. Thus the Polynesians form the word *lima*, *i. e.* "hand," into a numeral meaning 5. Thus the Caribs have made words expressing "hand," "both hands," "feet and hands," into numerals equivalent to 5, 10, 20. Even among the rude nations of West Australia, who are usually found to possess no numeral beyond 2 or 3, the formation of hand-numerals has locally broken out, as they have been found to use the expression *marh-jin-bang-ga*, or "half the hands," for 5, and thence to count on to 15, which they call "the hand on either side and half the feet." The immense series of facts of which these are illustrative exemplify the uniform results of a similar process of mental development which has occurred again and again among remote and savage tribes. As a second instance of such uniformity, examples were quoted from among a large number of the languages of the world, in which the interjections of affirmation and negation display a remarkable tendency to fall into vowels, mute or aspirated, as *aye, ii, hi*, &c. for "yes," and into labials, as *aan*, *nani*, &c. for "no." Thirdly, the repeated occurrence in remote and disconnected languages of the practice of "differentiating" by vowels pronouns and adverbs of distance, is to be ascribed to the uniform action of similar processes. Of this a single instance may be quoted from the Javan language, which distinguishes *iki*=this (close by), *ika*=that (at some distance), *iku*=that

(further off). Again, the popular notion of myths is that they are free and unrestricted growths of fancy, and that the study of such baseless, unsubstantial fabrics of the imagination can lead to no precise or scientific results. But wider knowledge must dissipate this idea by showing that myths are intellectual developments to be traced to definite causes, like other products of the human mind. Thus the myth that on a certain hill there was a battle of giants and monsters, will be probably interpreted by the fact that great fossil bones are really found on the spot. Again, the story of the presence of a race of men with tails in a particular district is apt to indicate the real existence of a tribe of aborigines or outcasts, like the Miautsze of China or the Cagots of France. The author dwelt especially on two "philosophic myths," invented again and again in the infancy of science to account for strictly physical phenomena. The Polynesian myth of Mafuie, the subterranean god who causes the earthquake by shifting from shoulder to shoulder the earth which he carries, and many other similar myths, come under the common heading of myths of an earth-bearer, formed in various regions to account for the occurrence of earthquakes. The myth of the Guaranis of Brazil, that a jaguar and a huge dog pursue the sun and moon and devour them, which causes eclipses, is an instance from the widespread group of eclipse-myths of a similar kind. On this and other evidence the writer argued for the possibility of discovering in the phenomena of civilization, as in vegetable and animal structure, the presence of distinct laws, and attributed the now backward state of the science of culture to the non-adoption of the systematic methods of classification familiar to the naturalist.

GEOGRAPHY AND ETHNOLOGY.

Address by Capt. Richards, *R.N., F.R.S., President of the Section.*

On the present occasion of opening the Section of Geography, and the science which has been associated with it, it is not my purpose to impose upon you any set address, or to enter into any of the detail of geographical research during the past year; and my reasons for departing from what appears to have grown into a practice of late, are, first, that the nature of my official duties have not left me the leisure to do so; and secondly, the geographical events of that period have been so amply dealt with by the President of the Royal Geographical Society, in his Annual Address delivered in May last, and printed in the Society's Proceedings, that a repetition of them seems unnecessary, and would probably be wearying. I shall, therefore, with your indulgence, in the few remarks which may occur to me on this occasion, confine myself to a consideration or brief review of the general state of our geographical knowledge, adverting to those portions of the earth's surface to which the attention and the labours of future explorers may be advantageously directed, and dwelling briefly on the results which are certain to follow those labours in the interests of knowledge and science, and of humanity, no less than in those of the national honour and credit, keeping in view, so far as I may, the present and the future, rather than the past.

The Science of Geography, as accepted in its ordinary and every-day sense, is within easy reach of us all: it requires no abstruse knowledge to follow its study or its discoveries, or to unravel its mysteries, if there are any; thus the navigator, the traveller, the ordinary observer may be, and are, geographers in this sense; yet, regarded under its many aspects, each of them bearing practically more or less on all that concerns the existence and well-being of the human race, limited only by the earth's surface which it is its province to describe, embracing as it does, within its sphere, most other branches of physical science, it must be confessed that is not the least important of them, nor is it surprising that it should be one of the most popular, or that men should have been found in all ages ready to sacrifice their ease and comfort, their fortunes, or to hazard their lives in the pursuit of any geographical adventure which might seem to offer a possible or even impossible path to fame and distinction.

In tracing the history and progress of geographical discovery, we find that maritime exploration always has been, and indeed necessarily always must be its precursor. When the coasts of a country have been thoroughly explored and defined on the map by the aid of astronomy and other branches of science, then, according to various circumstances (to the nature of the climate, the character and extent of the population, and other physical conditions), will the geographical features of the interior be developed with greater or less rapidity: all history and experience confirms this, and there are not wanting familiar instances within our own observation.

Wherever, then, it has been possible for navigation to penetrate, there the shores of the world are sufficiently known for all the purpose of geography proper, although in the interests of navigation itself, and of the commerce and intercourse of nations, we have ever been, and probably ever shall be, as long as the world lasts, adding to and refining on this knowledge. The science then, indeed, assumes other phases, such as Hydrography, and the Meteorology and Physical Geography of the ocean, the latter becoming every day of more interest and importance in a practical point of view, and therefore demanding in a proportionate degree the aid of science in its development.

In the physical geography of the ocean must be included a knowledge of its depths, the nature of its bed, its temperature, its currents at the surface and beneath the surface, and other information necessary to meet the requirements of the present age: for instance, without this knowledge it would not have been possible successfully to lay the submarine cables which now connect Great Britain with America, and which it is reasonable to suppose, so soon as the requirements of commerce shall justify the outlay of the capital, will be followed by similar ones, until the whole globe is encircled. France and America are about to be united by such a tie: a cable will probably be shortly laid through the centre of the Mediterranean Sea, connecting Gibraltar, Malta, and Alexandria, thence through the Red Sea, and across the Indian Ocean to Bombay; a portion of this will certainly be completed within a few weeks. The connexion of India with China on the one hand, and with Australia and New Zealand on the other, will probably not be long delayed. These great undertakings require not only a knowledge, but a very accurate knowledge of all the conditions I have mentioned, the obtaining of which demand an amount of skill and patience and perseverance on the part of both engineers and seamen, which those not fully conversant with the subject can little conceive. Our efforts, then, of late years have been directed to this end, and by the aid of science, and the modern mechanical appliances it has supplied, instead of the vague and imperfect knowledge which we possessed up to a comparatively late period, we are now in the possession of far more accurate data: we know the depth and nature of the bed of the North Atlantic between Europe and America by three different routes, and that it does not in any part much exceed two geographical miles, or about 13,000 feet. The Mediterranean Sea has been accurately measured, and its greatest depth has been found scarcely less than that of the Atlantic. But a few weeks since the Indian Ocean, between the Red Sea and Bombay, and over other portions, has been sounded with remarkable accuracy, the maximum depth obtained being something over two geographical miles. Between China and Australia a great portion of the distance has been accurately examined, and the remainder is at present in progress; while but a few days since accounts have been received of the bottom of the sea having been reached in the South Atlantic, between the Cape of Good Hope and the Equator, the greatest depth obtained being 18,000 feet, or nearly three geographical miles: and no doubt or uncertainty exists in any of these operations, for in all cases the bottom has been brought up in considerable quantities. I cannot myself but regard these results as of infinite importance, and second to none of the geographical discoveries of past years; many of them, indeed, are the results of the past year.

In connexion with this subject, I would desire to call the attention of those interested in it, to a series of Physical Charts of the Atlantic Ocean, lying on the table; they are among the latest of the labours of the Hydrographical Department of the Admiralty, and will in a few weeks be available to the public. The present and only copy has been pushed forward for presentation to the Section, and at no

distant time they will be followed, I trust, by a similar series for the Pacific and Indian Oceans.

Following up the progress of geographical discovery from early times, and under conditions which have been the most favourable, we find that in Europe and over the greater portions of North and South America, where freedom of intercourse and travel are unrestricted, we have comparatively little to learn.

Over the greater part of Asia also, throughout the great Empires of China and Japan, there is no reason to doubt but that the science of Geography is well understood and cultivated, although from the peculiar customs and institutions of these countries, and the jealousy of their rulers, they are still in a great measure closed to the observation and enterprise of Europeans.

Of that neutral ground, as it were, in Central Asia, between the northern frontiers of India and the southern boundaries of the Russian Empire, and in Western Tartary, which has been attracting much attention lately, there is yet much to learn, although through the zeal and enterprise of our own Indian officers on the one hand, and from the Russian armies of exploration, not to say encroachment, on the other, we are adding something to our knowledge each succeeding year; and but a few weeks since a traveller left these shores, under the auspices of the Royal Geographical Society, in the pursuit of new geographical encroachments in this region.

Even with the geography of the vast groups of Islands strewed over the Pacific and Indian Oceans, we are for the most part tolerably acquainted, thanks to maritime discovery, in many cases aided by the labours and researches of the church missions, which have taken no inconsiderable share in the work. But there is another side to the picture, and it must be confessed that it is a darker one. If we turn to Africa, even to Australia, to New Guinea, to Borneo (to that sealed book of the north lying almost at our very threshhold), the mind can barely contemplate the vast problems that geography has yet to solve, and we almost sicken at the reflection how little (how comparatively little) has resulted from all the great efforts and noble sacrifices which have been made by individuals in our own time and in the times before us.

Let us turn to Australia: here a great English nation may be said to have sprung up within the present generation, and yet scarcely more than a corner of it can be considered as fairly occupied; with its sea margin alone, and not even all that, are we thoroughly acquainted; and notwithstanding the dauntless energy and courage of the numerous explorers, too many of whom have given up their lives in the cause, it is no exaggeration to say that by far the greater part of the interior of this sea-girt continent is as little known as it was when Cook first visited its shores a hundred years ago.

In the interest, then, of any future explorations, the question seems to arise, To what causes are we to attribute the comparatively small measure of success which has hitherto been attained? It may be that there are undertakings beyond the scope of individual enterprise, or indeed of any enterprise not under the direct aid and auspices of a government; doubtless great physical difficulties existed, yet they were not in most instances underrated; means and resources may have been inadequate, organization and combination may have been wanting; but be this as it may, it is certain that as yet no effort has been made commensurate with the difficulties to be overcome and the importance of the results to be gained. A perfect knowledge of the geography of a country must doubtless inevitably follow, and not precede occupation and civilization; but these conditions exist now to a certain extent in Australia, and it does seem that the time has come when a combined effort should be made to clear up what must be almost considered a reproach to geography. Those who have read or studied the history of geographical discovery, cannot fail to have remarked how seldom any great results have been attained until after repeated efforts and many failures, and how often, when hard-earned experience has made success seem almost certain, the prize has been relinquished when almost within our grasp. This can scarcely remain the case long as regards Australia: an organized exploration of the interior indeed has been proposed, and is still under consideration; it has received the warm approval and countenance of the Geographical Society, before which a paper has been read on the subject by its

author, Dr. Neumayer, a resident of Australia, and intimately connected with most of its scientific intitutions; but on a question of such dimensions no Society can do more than give its sympathy: it is a problem for the united governments of Australia to solve, and it is to be hoped that when undertaken it will be with such adequate means, organization, and cooperation, both afloat and on shore, as will render failure impossible.

There is yet another *terra incognita* almost within view of the northern coast of Australia, in the great island of New Guinea, whose shores even have scarcely been correctly traced on the map. It has been visited, however, by navigators of different countries, and there is little doubt but that, like the smaller islands in its neighbourhood occupied by the Dutch, it is rich in all the choicest products of the earth.

It is to be feared, however, that the time is distant when this interesting country will be opened up to commerce and civilization; its great extent, and the hostility of the natives, among other causes, place it far beyond the reach of any individual efforts, and none of the maritime nations seem yet prepared or disposed to set their mark upon it.

I am unwilling to leave these southern regions without a few passing words on that latest acquisition, and perhaps most flourishing dependency of the British Empire, New Zealand: as an instance of the rapidity and success of exploration and colonization almost coincident with each other, it is probably the most remarkable in the annals of the world's history; undoubtedly it possesses in a high degree almost all the conditions favourable to such a result—an extent of country equal to Great Britain, of a form and distribution the most favourable for development by nautical exploration, with a climate admirably suited to Europeans—it seemed indeed to invite civilization.

Scarcely thirty years ago almost its sole white occupants were a few English missionaries, who, indeed, have generally been the pioneers of civilization in these distant regions; ten years later, when colonization was first seriously undertaken on a great scale, the sagacious nobleman then at the head of the navy, Lord Auckland, foresaw that the shortest and most certain road to success was a complete nautical survey of its coasts, which, under his auspices, was at once commenced, and completed within seven years. During this interval colonization progressed with rapid strides; and at the present time, despite the drawback of years of native wars, New Zealand, or, as it has well been called, the Great Britain of the south, is peopled throughout its length and breadth by Englishmen, in the possession of the luxuries, wealth, and prosperity of an old and long settled country.

There is one incident in the history of New Zealand which is not generally known or remembered, and it is an instance of what momentous results to a whole nation may sometimes arise from apparently trifling or accidental causes. The incident is this:—that but for the fortuitous presence of a little brig of war there in, I think, the year 1839 or 1840, commanded by the late Captain Owen Stanley, a name that will be familiar to many in this old city, that flourishing country, or at any rate the largest and fairest portion of it, would now have been under the flag of another nation, and there would have been the singular coincidence of a second English Channel at the Antipodes, with our opposite neighbours looking at us across what is now known as Cook's Straits.

I now turn to Africa, fruitful, if in no other respect hitherto, yet certainly in geographical adventure and daring; and if we do not approach the subject without hope as to its future, I think we must do so with feelings of misgiving and doubt. It is a mighty subject, full of the weightiest interests to millions of the human race—too weighty, indeed, to be more than touched upon here; and the few words I shall say will have reference chiefly to the great object of interest to Englishmen at the present time—the fate of the great traveller whose life has been so intimately associated with Africa, and who for the last two years and a half has been wandering almost single-handed over that great continent, in pursuit of the objects to which that life has been mainly devoted. For all we know of the interior of Africa we are indebted almost entirely to our own adventurous countrymen, and let us inquire briefly what do we know. We know that a vast chain of lakes exist, reaching nearly from the Zambezi on the south to the head waters of the

Nile on the north, though of their extent, their height, physical features, and the functions which they perform in relation to the mighty rivers of the great continent, much as we do know, much more is still left to conjecture; we know that the climate of the high lands of Central Africa is not unfavourable to the European constitution —that it has, or had a dense population, and has the resources of legitimate commerce and wealth within itself—that slavery, with its concomitant evils, exist in their most appalling forms, encouraged and fostered by the traders of nations professing to be civilized or semicivilized; but the one thing hopeful we do know is, that it is undoubtedly within the power of any civilized nation, and especially of this great country, which has banished slavery from its own empire and from the sea, to adopt measures which at an inconsiderable cost would strike an effectual blow at the source of this great evil. I have said that we have gained all this knowledge through the enterprise of our own countrymen. No words of mine could add anything to their well-earned fame. There will doubtless always be such men found who, for honour and renown, and in the search of knowledge and the love of science, will be ready to devote their means and their lives to such enterprise. Livingstone was not insensible to any of these high motives, but with him they were secondary and entirely subservient to the great dream and aim of his life—the blotting out of slavery in Africa and the regeneration of the race.

I am anxious now, if I can, to make it plain what are the probabilities or otherwise as to the safety of our great traveller. There is a mistiness on the subject in the minds of the public generally which is not surprising, and there is an anxiety among most of us which is natural, and for which, hopeful as many are, there is but too much reason. Livingstone has been in Africa now for two years and a half, and for eighteen months he has not been personally heard from. He left on his last expedition, it will be remembered, in March 1866, disembarking at the mouth of the Rovuma river, on the east coast, accompanied by eight of his own liberated Africans and ten natives of the Comoro Isles, who have since gained an unenviable reputation among geographers as the *Johanna men*. His intention was to strike the north end of Lake Nyassa with the view of settling the question as to its connexion with the North Lakes, and then to proceed on to Lake Tanganika; the hostility of the natives, however, in this region frustrated these plans, and he consequently bore away and crossed Nyassa at its southern end. Shortly afterwards he was abandoned by the Johanna men, who returned to the coast with a circumstantial account of his murder and of that of his whole party; and here, without being the advocate of these much-abused individuals, let me say a few words which I think are in justice their due. They were hired with beads and calico, and were bound to Livingstone by no other ties: during their journey to Nyassa they had been in imminent peril of being murdered by other savages, and as they preferred their own lives to roaming through Africa in pursuit of what they may be excused for considering a tour of mere curiosity, they took the first opportunity of returning, and like a good many other savages of different colours, they excused what they probably felt was a rather shabby proceeding by a resort to falsehood.

I have never, I confess, been able to understand why so much obloquy and virtuous indignation has been expended on these savages, or why so high a standard of morality should have been expected of them; I suspect Livingstone himself would have been slow to condemn them: it was his custom to surround himself with people whose safety was dependent on his own safety, and no doubt if he could have got the Mizitu tribes between them and the sea, the Johanna men would have remained faithful to him. However, their story was generally credited, and Sir Roderick Murchison was among the few who doubted it; principally, I may say entirely, through his exertions a small expedition was sent out by the Government under Mr. Young, of the Royal Navy, to ascertain the truth or falsehood of the report. Mr. Young ascended the Zambezi and the Shiré, and carrying his steel boat over the cataracts with great labour and perseverance, he got on to Lake Nyassa, where he soon obtained abundant proof that Livingstone had passed on in safety towards Lake Tanganika. Mr. Young returned early in this year, and has written an account of his successful search.

From Lake Nyassa to the native settlement of Ujiji on the east side of Tanganika,

where Livingstone's course was now directed, is over 700 miles, and by a letter received from himself, dated Bemba, 1st February, 1867, and brought to Zanzibar by traders, we know of his safety up to that date; he had then 400 miles to travel before reaching Ujiji, which he expected to do in June. He described in this letter the hardships he and his seven natives had suffered from hunger, the loss of his medicines, which was a real loss, and, to use is own words, he was little more than a bag of bones; still he wrote hopefully and in good spirits, as no one ever knew him otherwise, and this is the last positive information we have of Livingstone.

An ivory trader, who left Ujiji on October 6, 1867, and arrived at Zanzibar early in February 1868, reports that Livingstone had not reached that place when he left, but that he was expected, and that ten days afterwards he heard from native report that he had arrived a few days subsequently; therefore we have indirect information of his having reached Ujiji about the middle of October 1867. Before we speculate on his subsequent operations we may premise that he would have lost no opportunity of writing to Zanzibar an account of his discoveries up to that time with his future intentions, and this is the first information we must look for, and most anxiously we do look for it.

Assuming, however, that he did reach Ujiji during October 1867, he would have found there the medicines and other small supplies which were sent him at his own request by Dr. Kirk, our consul at Zanzibar; he would also have learned the discoveries of Sir Samuel Baker, and received his map, by which he would see that he might, from the head of the Albert Nyanza, pass down the Nile; but whether, supposing him to have chosen this route, he would have had sufficient goods and presents to have satisfied the rapacious chiefs whose countries he must have passed through is very doubtful, indeed unlikely.

But, arrived at Ujiji, Livingstone's real work would seem but to have begun: there were great problems to solve; there was the correct determination of the height of Tanganika to be established; its communication or otherwise with Victoria Nyanza and the new lake of Sir S. Baker, to be ascertained; the heights of both these great sheets of water to be corroborated; the extension of the latter to the southward and westward; all circumstances intimately connected with the great question among African travellers, which is the real source of the Nile; and the latter (that is, the extension of Albert Nyanza to the west) perhaps involving questions of equal importance to geographers, viz. the sources of the Congo and others of the great western rivers. With so much to do here, Livingstone was not the man to be lured away by the mere *éclat* of having traversed Africa from the Zambezi to the shores of the Mediterranean.

At Ujiji he would, with his people, have required a long rest after the fatigues of so considerable a journey, and difficulties and delays may have occurred which it would be useless here to speculate upon. As to his absence, the work there was before him is more than sufficient to account for it; the non-arrival of any direct intelligence from himself from Ujiji is the least hopeful feature of the case, though it is possible to account for this by the irregularity of the arrival of carriers at Zanzibar; those, however, who know the great explorer best are most sanguine of his safety. Some believe that he may reach the coast by the Atlantic, some by the Mediterranean, and others again by the Indian Ocean. If he is spared to return to us again, as all who know him must earnestly hope, on personal grounds, as well as in the belief that there are great things yet for him to achieve, I incline myself to the belief that it will be by Zanzibar; but until some positive information reaches us of his arrival at Ujiji, it would seem useless to institute a search in any other direction with a hope of success. Once establish the fact of his arrival or non-arrival there, which would not appear difficult to do, and the question is reduced to far narrower proportions.

I now approach a subject of geographical discovery which has always been received with favour in this country, viz. the exploration of the North Polar regions, but in order to a clear understanding of the present state of our geographical knowledge there, and the prospect of its future, I must revert briefly to the past.

So early as the middle of the sixteenth century the efforts of Englishmen were directed to the discovery of a passage from the Atlantic to the Pacific by the north,

or what is called the north-west passage; not only would such a passage infinitely shorten the distance to the Pacific and China, but it was the fashion in these days for each maritime nation to have its own route, and Spain and Portugal, with the good offices of the Pope, laid claim to the monopoly of the present highways of Cape Horn and the Cape of Good Hope. To possess such a short and exclusive one, therefore, close to our own doors, was a great inducement to persevere; many then were the efforts made, with no approach to success beyond additions to geographical knowledge, and after the middle of the eighteenth century Arctic enterprise appears to have slept for nearly a hundred years. The end of the long war, however, left the navy without much occupation, and the subject was again revived, chiefly owing to the able advocacy of the late Sir John Barrow, who was its consistent supporter to the end of his life. The voyages of Parry, Franklin, and others, in 1819 and subsequent years, to the west and the north are familiar to all. Parry, however, never succeeded in reaching further westward than Melville Island, in about the meridian of 115°; and no ship has ever since penetrated to the westward of his. The subsequent expedition of Franklin in the 'Erebus' and 'Terror,' which left England in 1845, and was never again heard of until M'Clintock discovered the records of its sad fate in 1857, was the last attempt to discover a north-west passage, though more in pursuit of scientific investigations than in the belief that any passage existed which could be turned to practical advantage. But it was this interval of twelve years which was fruitful in Arctic discovery. Expedition after expedition was despatched by the Government, from the east and from the west, in search of the missing navigators with the full approval of the nation, and with the frequent cooperation of the citizens of another nation (the United States), who shared with us some important geographical discoveries; and it was during these years that the north-west passage may be really said to have been made by a ship's crew, which entered the Arctic Ocean by Behring's Straits, and returned nearly four years afterwards by the Atlantic. But no ship has ever yet passed through this frozen ocean; though from the day that Parry first stood on Melville Island (in 1819) and looked out upon it to the westward, no reasonable doubt could be entertained but that there was water- or ice-communication between the two oceans.

The manner of the accomplishment of this passage was thus:—In 1853 M'Clure reached the Bay of Mercy in Banksland, where his abandoned ship, the 'Investigator,' now lies; at the same time lay the 'Resolute' at Melville Island, scarcely more than 150 miles distant; the crew of the former walked over the ice to the latter, and were conveyed to England in a third ship.

Whether another attempt will ever be made to force this 150 miles of ice or water is immaterial; it is certain that it can never be turned to any practical account; but that vessels will yet pass from one ocean to the other by this route many are sanguine enough to believe. The north-west passage, however, has been settled, and the great question with geographers now, and especially among those who shared in the labours and the honours of the search for Franklin and his companions, is the exploration of the Polar Sea and the discovery of the North Pole itself.

English naval men naturally look upon this as their inheritance, and are very jealous of it, though it may be in some respects a barren one. Geographers of all nations, while they earnestly desire its accomplishment, have, with one consent, generously accorded the honour of its fulfilment to us. The Council of this Association and the Royal Geographical Society of London have exerted all their influence to promote the undertaking; the great geographical authority of this country, Sir Roderick Murchison, has been a consistent and untiring supporter of Arctic enterprise, and geographers of all countries are deeply indebted to him, and have acknowledged their indebtedness; but I must take leave here respectfully to dissent from Sir Roderick when he infers, as I think he does, in his Annual Address, that the disagreement among Arctic men themselves as to the proper route to be followed has been the principal cause of no action being taken. I cannot think this: doctors frequently differ as to the mode of effecting a cure, but nevertheless it is very often effected, and by different modes. Geographers may differ as to the road by which they would prefer to reach the Pole; but there is no Arctic

officer of experience who does not believe that he could reach it, whether by Smith Sound or Spitzbergen.

Let it be remembered that we can never yet be said to have brought steam to bear upon Arctic discovery; that all our costly searching expeditions of late years have been searching for Franklin, and that all the discoveries they have made have been incidental to that search. Any one of those expeditions would certainly have discovered the North Pole if such had been the object; but even to look toward the Pole in these days was little short of treason. It must be admitted there are enthusiasts as well as geographers strong on this question: the eminent German geographer, Dr. Petermann, is so much an enthusiast in the cause, that at his own cost he has just sent a little vessel of eighty tons, without steam-power, to reach the Pole between Greenland and Spitzbergen; I wish I could hope that he would reap the success he deserves. But the error which, as I think, the advocates of Polar exploration have fallen into is that they look upon the Admiralty as responsible for the discovery of the North Pole. If there was an enemy there, or a known friend in distress, it would undoubtedly be their duty to look after either, but under present circumstances, it is no more within their province, as it appears to me, than to place a squadron of steel gunboats on the lakes of Africa to suppress slavery. I can imagine that nothing would be more congenial to the individual members of that branch of the Government than to adopt both these glorious expedients, which would reflect so much lustre on the country and on themselves; but it is the country that must do these things, and if the country wishes them done and will provide the means, they will be done speedily and effectually. The North Pole is just as much a public question, if I may make the comparison, as the Irish Church, and if canvassed, possibly might considerably affect the approaching elections. Perhaps one of the most powerful arguments in favour of Arctic exploration or Antarctic exploration at the present time is the necessity of educating officers and seamen in preparation for the great astronomical problem, which must be solved in a few years' time, as near to the South Pole as we can get; for it is difficult to believe that this country will not take an important part in the solution of that great problem; and Arctic seamen will not last for ever, nor can they be made in a year. I will only add further on this question of the North Pole, that it appears to me to be one of those cases of success all but attained, and within our grasp; and I trust that the country which has borne the heat and burthen of the day will not be robbed of the crowning honours.

There is another subject connected with geography in which I believe a large section of the public of this country feel a special interest, and which it would be improper therefore to pass unnoticed here. I allude to the research which has been, and is still being carried on in Palestine under the direction of officers of the Royal Engineers, and to the projected exploration of a portion of the Peninsula of Sinai, which it is hoped will be shortly commenced.

The latter project originated with the late Captain Butler, of the 55th Regiment, who made considerable explorations there, but on the breaking out of the late war was recalled to his regiment, and subsequently fell at Inkerman. It was afterwards warmly taken up by his brother, the Rev. Pierce Butler, supported by many friends, and but for the sudden and lamented death of the latter gentleman a few months since, it would doubtless have been now in progress. There is every reason to hope, however, that it is only postponed. A few hundred pounds in addition to the funds in hand will suffice to defray the cost of the undertaking, and a cause of so much interest is not likely to fail for want of public support. On the table will be found printed papers setting forth the objects of the expedition and the results which it is hoped will be attained. I will only add that the name of Captain Palmer, of the Royal Engineers, who has been selected to conduct the Survey, is a sure guarantee that it will be well and completely performed.

I have little now to add. I said I would dwell briefly on the practical results which might be expected to follow the geographical research I have briefly sketched out; but it appears to me they almost tell their own tale. There is one great result, however, I will advert to, and which, in the interests of this country and two of her great dependencies, I hope will not be long delayed, at least the commencement of it,—I mean overland communication between the dominion of Canada and

British Columbia on the shores of the Pacific. It is impossible, I believe, to overrate the importance of this work to all concerned; it will practically unite these two great colonies in British America, and open up a vast and fertile country where our surplus population may live under their own flag instead of seeking a home under another. It must be remembered that we are living side by side on that great continent with a people second to none in their enterprise and perseverance; that already they have carried a railway from the Atlantic almost to the Pacific, and that they are completing it under difficulties as great as any we should have to encounter; but a few days since I received a letter from our Consul at San Francisco, in which he says "the Pacific railway is rapidly progressing, and in 1870 passengers will be carried from New York to San Francisco in five days." If British America is to progress under the flag of this country, and if we are to maintain our commercial position in the Pacific and in China, we must not be slow to follow this example; geographers have done enough to prove that the undertaking is feasible; Canada and British Columbia are alive to the importance of it, and as to the latter, its very existence, I believe, depends upon it.

I will ask your permission still to trespass on your time for a very few moments on a subject which has lately seriously engaged the attention of the Council of the Royal Geographical Society, and which will probably be of interest to some present. I regret very much that Mr. Francis Galton, a distinguished and well-known member of the Association, should not have been present himself to introduce the subject to you, for it is a child of his own, and he would have done far more justice to it than I can. There has been a pretty general feeling among geographers that, popular as geography is in a practical point of view, it does not receive that attention at our great public educational establishments which its importance entitles it to; and when it is considered and acknowledged how essential an acquaintance with geography is in the pursuit of the study of history and other branches of education, this cannot but be regretted. The Council of the Geographical Society, then, with the countenance of the heads of certain of the principal schools of the United Kingdom, have decided to offer a certain number of medals to be competed for annually, for the encouragement of the study of geography, the first competition to take place in May 1869. The pamphlets containing the particulars of this proposal will be found on the table, and the object of mentioning the subject here is to invite a discussion on it, and that it may be known before the meeting of the schools in autumn; possibly those present who have sons eligible for the competition may feel inclined to encourage them to compete; this must be considered as a first effort on the part of the Council of the Society, and it is entirely due to Mr. Galton. If attended with success, it cannot be doubted but that it will be followed by further encouragement in the same direction.

I may not conclude these remarks without expressing my sincere regret (in which I am sure I shall be joined by all present) at the absence of the man who, above all others, has done so much for the advancement of the science which this Section of the Association represents. This Section, indeed, was his own creation; and I venture to think it has not been the least of his contributions to geography, great as they have been. I need scarcely say I allude to Sir Roderick Murchison. You will rejoice to know that it is no serious indisposition which keeps him away from us. In a letter received from him only yesterday he says to me, "Tell the Section that nothing would have induced me to be absent from the Association, of which I have been a constant attendant for more than thirty years, but the absolute necessity of rest." The truth is that he has devoted himself to public duties, and especially those connected with our science during the past year, in a manner that would have severely taxed the energies of a far younger man; and with all his hopefulness he cannot but have felt deeply the uncertainty attaching to Livingstone's fate. I believe myself that the hope nearest his heart is once more to welcome home this great man, great in every sense of the word; and we must all earnestly hope that so fitting a consummation of a long and distinguished public career may be in store for him.

I am aware that it may be questioned whether this is the place or the occasion to record an obituary notice; and, indeed, the one I shall allude to has been already recorded in a more fitting place, and by one more entitled to pronounce it; but

there are exceptions to all rules, and I believe the Association would not excuse me if I were to omit on their behalf a passing tribute of regard and respect to the memory of one whose benevolent and familiar face will be mournfully missed by many here to-day, and whose long and industrious life was passed, even up to its latest days, in the pursuit of every object which could tend to the acquisition of knowledge or the advancement of science—to the memory of John Crawfurd.

And now it remains only for me to thank you for the patience with which you have followed me through these rambling remarks, which have extended far beyond the limits I had intended.

You will remember that on the occasion of the delivery of the President's Address last evening allusion was made by one of the speakers to the "*cohesion of atoms*," or the affinity between certain particles. I do not fancy that Professor Huxley applied the remark in a scientific or philosophical sense, but rather as a metaphor implying the attraction or drawing together which existed between two seafaring atoms, such as the President and himself; and it was precisely this feeling which, when Dr. Hooker did me the honour to ask me to preside over this Section, prevented me from saying what I really felt prompted to say—you had better find a more competent authority; and this is my apology for having accepted the position. I certainly have felt a pride and satisfaction in being associated with men whose early predilections in the search of knowledge and of truth led them to adopt my profession as affording the widest scope to careers which have since led to eminence, though the very attainment of that eminence has necessarily removed both to a sphere of wider and more extended usefulness.

On the Victoria and Albert Rivers, North Australia. By T. Baines.

On the Native Races of Abyssinia. By Dr. H. Blanc.

Isolated by the arid regions which surround it, the elevated region of Abyssinia forms a gem apart in torrid Africa, the perfection of a temperate and healthy climate. The people of Abyssinia are a mixed race, the offspring of divers invaders; and it is doubtful if such a thing as a pure specimen of the primordial Abyssinian race at present exists. The Shankalas, a negro tribe who dwell in the woods of the low country on the north-western frontier, are certainly not that race. They are a dark-skinned, woolly-haired, flat-nosed people, ignorant and fetish-worshipping, clad in the skins of animals and armed with the club. It was not probable that they were originally inhabitants of the highlands, driven to the malarious jungles which constitute their present abode by a superior race of invaders. The oldest records represent the Abyssinian race as powerful, enterprising, and possessing a civilization superior to that of other African peoples; and it is probable they have since degenerated from their ancient condition. The Abyssinians of the present day are a mixed race, in which the Arab, Jewish, and Galla elements are more or less combined. The first of the divisions of the race admitted by themselves is the *Amhara*, a word which serves to designate the majority of the population. The Amharas are all Christians. They are a handsome and prepossessing people, well proportioned and with large heads, in which there is but a slight preponderance of basilar development. The face is small in proportion to the cranium,—the eyes large and black, but somewhat devoid of expression,—the nose straight, or slightly curved,—the lips small, often rosy,—the beard generally scanty,—the teeth white and even,—the hair coarse, curly, sometimes woolly and sometimes long. The hue of the skin varies from dark brown to a dirty yellow. The language is an impure *Geez*, with a mixture of Arabic and Galla words. The people of Tigré inhabit the greater portion of the northern provinces. They differ but slightly from the Amharas; the head and face are somewhat longer,—the teeth more irregular, long, and prominent,—the eyes smaller and brighter,—and the face more angular; the hair, especially of the women, is longer and finer. They are generally darker than the Amharas, and the Tigré dialect has still more connexion with Geez. The people of Lasta seem to combine the best points of the Amharas and Tigré nation; although they are below the middle height they

are remarkably well made, and notorious for their strength and agility. They speak the Tigré dialect. The people of Shoa as a rule are darker and taller than the Amharas, but speak the same language. In Tigré and Shoa a large portion of the people are Mohammedans. Besides these four sections of Abyssinians there are several separate tribes. Of these, the *Falashas* are the most important: they are found in great numbers in Wolkait, Waggara, and Koura, and are undoubtedly of Jewish descent. To this day they have retained many of the customs of their race, observing the Sabbath and being very particular in their food and other observances of the Mosaic law. Another tribe are the *Kainawnts*, a peculiar people inhabiting the district at the north-western extremity of Lake Tana. They resemble in appearance the Falashas, and are not improbably a derivation from the same tribe. They observe the Jewish Sabbath, and retain some of the Jewish prejudices. Although they have a sacred language of their own they speak Amharic. They are a quiet and inoffensive people, but so brave in the defence of their homesteads and sanctuaries that they are but seldom molested by their crafty but cowardly neighbours the Amharas. A third tribe are the *Agaws*, who are of Galla origin, and inhabit districts at the southern end of Lake Tana and to the westward of Lasta. They are fairer in skin than the Amharas, have handsome features and are remarkable for the delicate form of their hands and feet, and for the fine texture of their hair. The land of the Agaws, bordering on the district of Damot, is one of the finest provinces of Abyssinia. These Agaws form a wealthy and powerful tribe. When Mr. Rassam's mission (of which the author was a member) passed through their country their hospitality knew no bounds, and their amiable and courteous manners and pleasing smiling faces will ever be remembered. Although they have Christian churches and priests they are not looked upon as orthodox by the Amharas. They are a courageous people in defence of their homes, and the Emperor Theodore always took care to leave them alone. A fourth people, the *Zalans*, are rather a caste than a tribe; they inhabit Dembea, isolated in small villages, tending their herds of cattle, and are uncouth in appearance. The *Waitos*, a fifth tribe, inhabit the shores of Lake Tana, and are despised on account of their predilection for the flesh of the hippopotamus. They are expert fishermen and ply the lake in their bulrush canoes. Their hair is short and woolly, but they have no further resemblance to the negro Shankalas. A sixth tribe, the *Figens*, inhabit a well-wooded country, south of Lake Tana, abounding in elephants, which they hunt, and bring the ivory twice a year to the markets of Godjam. A seventh and last tribe are the *Wallo gallas*, a large, wealthy and powerful tribe inhabiting the fine plateau that extands from the Bechilo to Shoa. They came originally from equatorial Africa about the middle of the sixteenth century, and are a brave race, professing the Mohammedan religion. Now that their great enemy Theodore is no more they bid fair to overrun Abyssinia, and impose on the debauched and sensual Christians the false creed of the Koran. There is nothing to praise in the character of the Abyssinians in general. Beggars infest the land; the priests are ignorant and bigoted. The people are adepts at low treachery, lazy, pretentious, and pompous. If their timorous nature made them recoil from the daring act of murdering the white men, their guests, they enjoyed at least for a while the idea of their importance, and swaggered, full of pride, before the few helpless individuals their king detained in captivity and in chains.

On the Past and Present Inhabitants of the Cyrenaica.
By Commander Lindesay Brine, *R.N.*

During service in the autumn of 1867 and the spring of the present year, the author was instructed to proceed to the African coast, between Berenice on the west and the Egyptian frontier on the east, a region embracing Lybia and that fertile strip of Africa called the Cyrenaica. It is the author's object to give a sketch of the condition and nature of the tribes now settled among the plateaux and ruined cities, and to describe the traces that remain of earlier civilizations. Although Cyrene, the capital of the Greek colony, is almost buried, it yet presents on the

sides of its ancient roads and on the faces of the valleys the most artistic and extensive rock-cut tombs in the world. The excavations conducted by Commander Porcher and Major Smith, R.E., had also revealed sculptures not inferior to those of the best period of Greece. The coast was dangerous to approach by sea, a defect mitigated during Roman occupation by the construction of harbours. Cyrene is situated on the summit of hills overlooking the sea at a height of 2000 feet. After the cities were destroyed by successive barbaric invasions on the fall of the Roman Empire, tribes of Bedouins occupied the region, and pitched their tents under the shadows of amphitheatres and Christian churches. The fanatical Islamism of other countries of Northern Africa is unknown amongst the present inhabitants of the Cyrenaica, who only comply with a few of the external forms enjoined by the Koran. They are incapable of comprehending the significance and grandeur of the ruined cities they occupy, or of profiting by this beautiful and fertile tract of country. The present population consists of three socially distinct classes of Arabs—the stationary, or city Arab, the armed Nomads, and the Bedouins. On the eastern frontier there is a mixture caused by the importation of Nubian or negro slaves. At Bengazi (the ancient Berenice) may be seen every possible shade of mixture, the result of cross-breeding. The chief elements are the fair and high-bred Arab, the tall, well-shaped, black Nubian, and the woolly-haired negro; a resident Turkish garrison also takes its part in the general mixture. The Cyrenaica consists of a long strip of table-land, bounded on three sides by the desert, and on the fourth by the Mediterranean. Its geological formation consists of limestone, and the rock is much hollowed by caves. The country is remarkably fertile, and nothing can exceed the beauty of the scenery on the heights and among the ravines. From the upper plateau, on which Cyrene was built, the land descends in terraces to the coast, and it is on the slopes of these terraces that the Bedouin wanderers are most seen. They are physically a finer set of people than the Bedouins of Syria, and more warlike and aggressive. When young, their skin is bronzed but very soft, and their dispositions timid and gentle; but as they grow older they become darker, their voices rough, and their manners thievish and treacherous. The women do much to destroy whatever charm Nature has given them by the habit of tattooing and, in some tribes, of slitting the right nostril. It is also common for mothers to lengthen the lower lips of their female children and tattoo the inside, carrying over the lines of tattoo down to the chin. The Bedouins keep their type pure and their customs distinct; nowhere can there be detected among them any mixture of race. Negroes are sometimes employed as labourers and are treated kindly; but the author doubted if they are allowed to take a wife out of the tribe. The Bedouins with their cattle settle on the maritime plain in the spring and autumn, obtaining their supply of water, after the rains, from the old Roman reservoirs or wells. They have but few camels, but goats in abundance. Many families find excellent shelter in the numerous limestone caves, which also serve for herding the goats. On the plain are numerous surface cavities with small openings, which are used as *caches*, for the purpose of storing the fodder when the Bedouins retire to the upper grounds. The rock-cut tombs at Cyrene are inhabited by the Sheikhs and other chief Arabs. A large entrance, raised slightly above the road, opens into a chamber of considerable height and size, and this usually communicates with smaller chambers formerly used as sarcophagi. In one of these tombs the author was received by the governor and his staff on the occasion of his official visit. The Nomad tribes are dangerous and aggressive. The men are never without their guns, and if superior in numbers are menacing to strangers. They have a facility for rapidly converging upon any given point in considerable numbers; and although many parts of the coast appear uninhabited, there is no part where, in a few hours, some hundreds of armed Bedouins would not assemble. On one occasion, when examining some ruins on an apparently uninhabited plain, covered knee-deep with wild roses, camomiles, and oleanders, the author and his party of officers and men were surprised to observe, in the course of half an hour, streams of Bedouins running down the neighbouring ravines to meet them. The Arab Nomads are not a joyous race; they have no amusements or games, and by disposition are sullen and solitary.

Physical Geography of the Queen Charlotte Islands. *By* R. Brown.

These islands, situated off the north-west coast of America, were first discovered by Juan Perez in 1774, in the Spanish corvette 'Santiago'; but they owe their designation to Capt. Dixon, of the merchant ship 'Queen Charlotte', who visited them in 1787, and applied the name of his ship to the group. Of late years the discovery of copper and gold on these islands, and their proximity to the colony of Vancouver's Island, had attracted more attention to them; but their coast line is still imperfectly known and their interior is entirely unexplored. The author spent a few weeks on them in the spring of 1866, and was enabled to obtain some information regarding the islands and their productions. The chief islands are three in number, separated by two narrow channels. Their western shores are much more rugged and precipitous than their eastern sides. Deep sounds enter the coasts in many places dividing the land into numerous peninsulas. The whole surface is densely covered with forests, chiefly of coniferous trees and a thick undergrowth of shrubs, rendering land exploration extremely difficult; it is possible, however, to investigate a large portion of the country by boats through the narrow inlets, which in some cases nearly meet from opposite sides. The forests contain no deer, and are nearly destitute of large game for food. The general geological structure of the islands appears to be beds of conglomerate, coal, and metamorphosed sandstone resting on erupted greenstone. The coal has all the appearance of anthracite, altered by igneous rock in a remarkable manner. Two companies have made efforts to work these mines, but hitherto without much success, the seams of hard anthracite being varied with masses of soft powdery material, like wet gunpowder. A fine slate associated with the coal is easily carved, and is extensively used by the Indians for making ornaments, such as elaborately ornamented pipes, flutes, images, &c., for sale to the whites; and many have found their way to European museums. In the metamorphosed sandstone, casts of a bivalve shell are seen in considerable numbers. Copper, chiefly in sulphates and carbonates, has been found at several places. Though situated so far north (between 51° 55′ and 54° 20′ N. lat.), the climate is much milder than that of the mainland further south. Great humidity prevails, as in the rest of the zone of coastland north of Frazer river, and including Sitka. On the 1st of April, when the author first landed, all the snow had disappeared from the lowlands, and the weather was mild and pleasant; towards the end of the month humming-birds made their appearance. The Indians (who are still the only permanent inhabitants) are known by the general name of Hydahs, and form one homogeneous people. Physically they are a finer race than is anywhere to be seen on the North American continent. The women are very good-looking, often tending to *embonpoint*; but they have a custom of disfiguring the lower lip by transfixing it with a large bone ornament, causing the lip to protrude in a shell-like form. Both men and women have erect, tall figures. The head is well formed, and not disfigured by compression, as in most of the southern tribes. Their hands and feet are small, and well shaped. The colour of the skin is fair, and in the women there is a mixture of red and white in their cheeks not seen in any other American race. The eyes are horizontal. Few of the men have any beard or whisker, but some have a bushy moustache and "imperial." Tattooing is sometimes practised, in patterns, on the back of the hands and arms, and, in the women, a few slight streaks on the cheeks. The average height of the men is 5 feet 10 inches, some of them reaching 6 feet, and their gait and bearing are dignified, totally different from the lounging, waddling walk of the flathead tribes of Vancouver's Island. The Hydahs are bold warriors, but cruel and vindictive; though generally friendly to visitors they are not to be trusted, and have been guilty of attacking and murdering the crews of small trading vessels. The claim of territorial rights and family pride prevail to a great degree amongst these people. Every head man has his arms, which are beautifully engraved on large copper plates in most grotesque quarterings, and on boxes and other articles belonging to his family. The plates are about 3 feet long by $1\frac{1}{4}$ broad, rather arched, and about a quarter of an inch thick. The Hydahs excel all other tribes of the red man in artistic skill, especially in carving, although their only tools are generally a broken knife and a file. Gold bracelets of elegant

design, busts in slate and ivory, and designs for iron railings to public buildings in Vancouver's Island have been executed by individuals of this tribe. Engravings of Assyrian sculptures in the 'Illustrated London News' have served them for copies of these objects in slate. Their language differs from that of all other Indian languages of North America, and is spoken with slight variations throughout the islands; the author stated his intention of giving the vocabulary he had noted down, in a general account of the Indian languages of North-western America which he was about to publish. No sort of cultivated plant is grown by the Hydahs except potatoes, which are produced in greater abundance than by any other Indian tribe, and are of excellent quality.

On the Formation of Fïords, Cañons, Benches, Prairies, and Intermittent Rivers. By R. Brown.

With regard to fïords, or deep narrow inlets in hilly sea-coasts, the author pointed out that they existed only in high latitudes. They varied in length from two or three miles to one hundred or more, and were known by the different names of inlets, canals, fïords, and lochs. Their nature was everywhere similar, so much so as to suggest a common origin. The author had investigated them on the north-west coast of North America; the soundings in them showed a great depth of water, high precipitous cliffs hemmed them in on both sides, and at their head a valley generally existed. They existed on the western side of Vancouver's Island, but not on the eastern, showing that the island once formed part of what is now British Columbia, its western coast being then the shore of the contiment. Jervis Inlet might be taken as the type of these inlets; it is forty miles in length, while its width rarely exceeds one mile and a half; the depths below almost rival the heights of the precipitous sides; bottom is rarely reached under 200 fathoms, even close to the shore. The author concluded that glaciers were the agency by which inlets were scooped out, in all parts of the world where they are now seen. Everywhere in British Columbia marks of ice-action are seen on the sides of the fïords. Not far from the heads of most of them glaciers are now found in the Coast Range and Cascade Mountains, and marks of old glacier-action can be seen 2000 to 3000 feet below the summit, and even near the sea-margin. Cañons, or the deep ravines through which many rivers of Western America for many miles pursue their course, the author attributed to erosion by the fluviatile currents, the action of which was stronger during the period when glaciers filled the northern fïords, and when the atmospheric precipitation would be much greater over the whole region than it is now. Benches, or terrace-like formations on the sides of narrow river valleys, far above the present level of the rivers, were due to sudden sinkings of the level of the rivers, on the wearing or breaking down of rocky barriers which impeded their course, thus leaving the traces of their old beds in the form of "benches." The existence of Prairies, or treeless plains, in the interior of North America was attributed by the author to the same cause as the formation of steppes and deserts in other parts of the world, namely, the deficiency in the rainfall in the interior of continents. Under the head of "intermittent rivers" the author enumerated the streams of this nature that he had observed on the eastern side of the Cascade Mountains in Oregon and Washington Territory, and explained them by the general aridity caused by the interception of the rain-supply from the Pacific by the Cascade Range, by the sudden melting of the snows on the Rocky Mountains, where the rivers mostly take their rise, and by the cavernous, volcanic nature of the surface.

On the Great Prairies and the Prairie Indians. By W. Hepworth Dixon, *F.L.S.*

On the Sepulchral Remains of Southern India. By Sir Walter Elliot, *K.S.I., F.L.S.*

In most parts of India ancient monuments of the dead are found, the relics of people that no longer exist, or whose descendants, if not wholly extinct, do not

now resort to the same practices. The most common kind are circles of rough stones placed close to each other, in which are deposited one, or sometimes two or three terra-cotta vessels containing burnt bones and beads or metal utensils. Others of greater pretension are formed by four large stone slabs inclosing a square space, and covered by a fifth slab forming a lid. The front stone, in some cases, has a circular hole in the centre or at the upper edge, which the country people believe to be an entrance to the dwellings of an aboriginal race of dwarfs. Sometimes the structures, which pass under the general name of *Pandu-kulis*, are oblong, and consist of two slabs on each side and two covering stones. These are occasionally divided by an internal slab into two chambers. The *Pandu-kulis* are for the most part above ground, but some have been found below the surface and covered with earth. Another sort is peculiar to the Malabar or Western Coast and the table-land above it. They consist of a subterranean chamber, excavated to receive an earthen vessel 4 or 5 feet deep and 3 or 4 in diameter, like a Roman amphora, containing the relics, the whole covered by a large discoid stone, which, from its resemblance to a native *kodi* or umbrella, has received the name of *Kodi-kal*. Similar convex slabs, propped on three or four upright stones, occur with them, and bear the name of *Topi-kals* or "cap-stones;" but no remains have been found under them.

The structures on the Nilagiri Mountains in Southern India, which formed the more immediate subject of the paper, differ from all these. Some, crowning the summits of the hills or elevated ridges are circular walls, constructed of rough stones, having much the appearance of the old-fashioned draw-well. Others are formed of tall, unhewn stones set on end, and inclosing a circular space. A third kind are excavated and lined with similar upright slabs, from which the earth outside slopes down on all sides. A fourth description are conical earthen mounds. In all these, however much they differ in form, the internal arrangement is the same. On digging out the soil from the inner circle one or more horizontal narrow slabs are discovered, always lying N.E. & S.W., the intervals between which and the external boundary are filled with broken pottery of a peculiar character, being the remains of tall cylindrical vases, without feet or handles, formed of a succession of rings, as if turned on a lathe, with lids surmounted by grotesque figures of men or animals, and sometimes by monstrous shapes, the products of the potter's fancy. Underneath each horizontal stone is a flat vessel of finer pottery containing the deposits, generally consisting of fragments of burnt bone, gold ornaments, metal cups and tazzas, iron (or more rarely, bronze) implements, as knives, spear-heads, sickles, razors, &c., mixed with a little fine black or brown mould.

The paper then went on to describe minutely the excavation of two of the more remarkable deposits, with the articles found in each, and concluded by an inquiry into the people who had formed them. These were traced to a race called Curumbars, formerly the dominant inhabitants of the Dekhan. They professed the Buddhist faith, were eminent for the culture of literature and the arts, but were destroyed utterly in a religious persecution headed by a Chola King of Tanjore, in the sixth century. This would give the tombs an antiquity of from 1600 to 2000 years. The æra so assumed is supported by the fact of a number of irregular-shaped silver punch-coins having been found in a kodi-kal tomb in Coimbatore, which were exactly similar to another deposit discovered in the same district, among which was a denarius of Augustus—by no means a rare occurrence, a large number of Roman coins having been dug up from time to time not only in Coimbatore, but in other parts of Southern India.

On the Peninsula of Sinai, and its Geographical Bearings on the History of the Exodus. By the Rev. F. W. Holland.

The author had twice wandered through the Peninsula of Sinai on foot, tracing its wadys, chiefly with a view to ascertain the route of the Israelites. The author discussed, in the first place, the evidence for fixing the position of Mount Sinai itself. The long range of Jebel Tih, forming a remarkable barrier across the peninsula, enables us to decide that the Mount must lie to the south of this line; and

within this limited region the claims of three mountains had been advocated. Of these, the first, Jebel Odjmeh, in no way met the requirements of the Bible narrative, being a mountain not apart from others round which bounds could be placed. The second, Jebel Serbal, was excluded by reason of its having no plain before it, and being approached only by narrow, rocky wadys. The third, Jebel Mûsa, the "mountain of Moses," standing alone and rising abruptly from the plain of Wady Er Rahar, seemed to answer most of the requirements, and is, the author believes, the true Mount Sinai. Yet there are many who believe that the plain in front of it, which is only two miles long and scarcely half a mile broad, is too small for the encampment of the Israelites. The author was surprised last year to discover another plain, similarly situated, at the foot of an imposing mountain, which was at least four miles broad and seven miles long; and this being only eight miles distant from Jebel Mûsa, is a striking proof of how little we yet know of the topography of the country. This plain is called Senned, and its mountain Jebel Um Alowee. Up to within the last five miles, the road which leads both to Jebel Mûsa and Jebel Um Alowee is identically the same; so that if the latter be ever brought forward as a rival Mount Sinai, it will in no way tend to unsettle any opinions that may be formed with regard to the previous route of the Israelites. The author next described the situation of Rephidim, which he believed he had satisfactorily determined to be at a spot about twelve miles to the north of the two mounts, where there is a narrow pass through a granitic range, formed by the Wady Es Sheikh, suitable as the post of defence of the Amalekites. All the requirements of the scriptural account of the battle of Rephidim were found at this spot. With regard to the route of the Israelites before reaching this point, the author believed that further research might possibly prove that a large plain called Es Seyh, south of Jebel Tih, extending for a distance of nearly thirty miles, had the highest claims to be considered the *Wilderness of Sin*; the distance from the south-eastern end of which to Rephidim was about thirty miles, and would correspond with the three days' march of the Israelites. Along this they may have marched after their journey along the sea-coast as far as Wady Ghurundel, and inland round the back of the headland of Jebel Hummam to Wady Useit. The author had arrived at the conclusion that no great change in the features of the peninsula of Sinai had taken place since the remote period of the Exodus.

On the Nomade Races of European Russia. By H. H. Howorth.

Russia, as the scene of the latest ethnographic changes, offers a good field to begin an inquiry into the earlier ethnology of Europe, it being, according to the author, a more scientific method to commence such an inquiry with the known, working back to the unknown, than the reverse process. A wide induction from facts and a careful balancing of authorities had led him to a generally consistent theory on the peopling of southern Russia by successive waves of nomades,—a story which is very confused as told by earlier writers. The following is a brief summary of the results:—In 1630 the Kalmucks first crossed the Volga with a few Turcomans in their train. Their number had since decreased very materially, and they are all found in the government of Astrakhan. In 1218 the Tartars, or Turcic race, officered by Moguls, crossed the same river, and subsequently founded the three Khanates of Kasan, Astrakhan, and Crim, which were successively swallowed up by Russia. Previous to 1218 the valley between the Jaik and the Volga, known as the Kisschabe, was occupied by a corrupt Turcic race, represented mainly by the Nogais, while in the Western Steppes were found Comans and Petcheneys, both also Turcic races. The extension of the power of the Khalifat and the spread of Islamism first brought the Turcic races in contact with the Volga. In the ninth and tenth centuries they drove the Ughry out of their settlements,—a portion of them, the Voguls, northwards; the rest, the Magyars, westwards into Hungary. Previously to this date the Turks were unknown in Western Europe. Under their several names of Huns, Avares, Bulgars, Khazars, and Hungars, or Hungarians, wave of invaders had succeeded wave across the Steppes, and gradually infiltered their blood and even a trace of their language into Central Europe. But these races were all Finnic or Ugrian. They all came from the same area, the crowded

cradle-land of Great Bulgaria and Great Hungary, and were essentially the same race under different names. This southward extension of the Ugrian race (the underlying race of all the European area) at so recent a period is an important fact, and seems to offer a key to the unlocking of that Pre-Aryan period of European history known as Pre-histoiric.

Rivers and Territories of the Rio de la Plata. By T. J. Hutchinson, *H.M. Consul at Rosario.*

On the Tehuelche Indians of Patagonia. By T. J. Hutchinson, *H.M. Consul at Rosario.*

Topography of Vesuvius, with an account of the recent eruption. By J. Logan Lobley, *F.G.S.*

The topography of Vesuvius was described in detail in this paper, which was accompanied by a map showing the points of interest on and around the volcano, as well as the courses taken by the lava streams emitted during the eruption of 1631 and the succeeding eruptions of the last and present centuries. The portion of the surface of the mountain covered by the lava of the late eruption up to the time of the author's ascent, was also indicated on this map. The author then pointed out that the mountain previous to the first of the historical eruptions, that of A.D. 79, was a simple widely-spreading cone having a single great crater, and that it then had every appearance of being an extinct volcano. Besides overwhelming Herculaneum, Pompeii, and Stabiæ, the eruption of 79 left another great memorial of its occurrence in the destruction of half of the enclosing wall of the great and ancient crater, and in the formation of that which has gradually grown, by the accumulation of the ejectamenta of successive eruptions, to be the present great cone of Vesuvius. It was thus that this memorable catastrophe changed Vesuvius from a simple truncated cone to the double-peaked and picturesque mountain of modern times, to a portion of which the Italians give the name of *Monte Somma*, and to the remainder *Vesuvio*. This part of the paper was illustrated by a series of diagrams showing the changes which have successively taken place in the form of the volcano.

The succeeding portion of the paper described the author's ascent to the crater during the eruption of 1868, and gave particulars of the phenomena displayed by the volcano and observed during the month of March in that year. The inclination of the sides of the great cone was found to be 40°, and the lava was flowing in many small streams near the Hermitage at the rate of 300 yards per hour.

The Gold-field of South Africa. By Dr. Mann, *Superintendent of Education and Special Commissioner of the Natal Government.*

In this paper Dr. Mann described Carl Mauch's discovery of old workings for gold on the high ground between the Limpopo and Zambesi rivers. Herr Mauch has been for some time bent on making his way through the African continent from south to north. He started from Natal some four years since, and in 1864 was in the Transvaal territory. In that year he accompanied an old, well-known elephant hunter, Mr. Hartley, on one of his expeditions beyond the Limpopo. The trip led them from the neighbourhood of Pretoria across the Limpopo, and along its west side, until the river entered upon its eastward bend, when the hunter climbed a high granitic table-land forming the water-shed between the Limpopo and Zambesi rivers in Mosilikatze's territory, about the 28th meridian of longitude. In this region, on the 27th day of July, Mr. Hartley directed his companion's attention to some curious holes that he had stumbled upon, obviously made artificially in masses of quartz rock. Herr Mauch found in the situation indicated a vein of quartz rock about 4 feet thick, penetrated in one place by a pit 10 feet in diameter, and containing at the bottom fragments of quartz, slag, coal, ashes, and broken blast-pipes made of clay. On commencing his search he lit upon a considerable

number of other pits scattered about in various directions, and from these pits he collected bright lead-ore containing silver, and fragments of quartz rock impregnated with gold. The pits were spread over a tract of land about two miles long and a mile and a quarter broad. The exploration was subsequently carried in a north-east direction to within 40 German miles of the Portuguese settlement of Tete, on the Zambesi; and other tracts unquestionably gold-bearing were noted. A limited number only of gold-bearing specimens of rock were taken away, in consequence of the jealous watching of natives appointed for the purpose by the chief; but precious metal of the value of 200 dollars was extracted from one of the fragments.

The distance from the Megaliesberg, in the Transvaal, to Mosilikatze's chief place was found to be 224 hours of actual travelling by ox-wagon. Gold was observed through a territory stretching around this centre for about 200 miles in a direction from south to north. The southernmost part of the gold district lies on the Umkosi river and in a mountain-range to the east of Mosilikatze's Kraal, and also at Kumalo, near the 19th parallel of south latitude. The water-drainage of this part of the country is southwards into the Limpopo. The northern part of the district lies upon the rivers Sechwechene, Sepakwe, Umzwerve and Umfule, all tributaries of the Zambesi, and flowing to the north. The southern portion of the auriferous tract is upon about the same meridian of longitude as the mouth of the Kei river, the northern portion on the same meridian as the capital of the colony of Natal.

Carl Mauch entertains no doubt whatever that there is a very large and rich tract of gold-bearing land in this high table. It is well known that gold is worked for Portuguese goldsmiths at Tete, and that it has been exported for a long period of time from Sofala, possibly the source whence it was sent to Ophir, in the Persian gulf, in the days of Solomon. It appears almost certain that Carl Mauch has stumbled upon the great source whence the gold of Tete, and of the ships of Tarshish, has been primarily derived, and that there were rude workings, most probably by natives, for procuring the precious metal on this very spot in past times. In one place there was a vein of quartz that had been worked out to a depth of six feet, and that had then been filled in with earth, in which trees seven inches in diameter were now growing.

Very considerable attention has naturally been drawn to the discovery of Herr Mauch, who had gone down himself into Natal to communicate his observations in detail to the colonial authorities. Various prospecting and exploring parties were in the course of formation, and there is no doubt that under the powerful influence of the proverbial "sacra fames" the exact character and value of this interesting district will shortly be ascertained.

On the Physical Geography of the Portion of Abyssinia traversed by the English Expeditionary Force. By Clements R. Markham.

The region traversed by our military expedition consists of a series of mountains and plateaux, extending north and south upwards of 300 miles, and forming the water-shed between the Nile and the Red Sea. It is divided, with reference to the streams which form the sources of Egypt's fertility, into three distinct regions:—1. The region drained by the Mareb; 2, that drained by the Atbara; and 3, that by the Abia, or Blue Nile. From the eastern flanks of these mountains only small torrents flow down, which are dried up by the scorching heat as they approach the Red Sea; while on the western side the rivers have long courses through deep valleys. But the Abyssinian highlands, though from their elevation of 7000 to 10,000 feet above the sea they enjoy a delightful climate, are not so favourably situated with regard to moisture as several other temperate regions within the tropics. But a small sprinkling of rain falls on the eastern coasts, opposite the arid wastes of Arabia, during the winter and spring months, when easterly winds prevail. Abyssinia has to look to the equator for most of her moisture, when the sun marches to the north, after having pumped up the necessary water from the Indian Ocean. Then, from June to September, she gets her rainy season; for her mountains are high enough to reach and condense the moisture that is hurrying northwards, and to bring it down to deluge and fertilize the plateaux and valleys. As the clouds progress northwards much of their moisture

has already been discharged, and the northern part of the country, which is drained by the Mared, is consequently much drier than the more southerly provinces. The first part traversed by the British troops comprised the southern portion of the province of Akula-guzay and that of Againé. It consists of plateaux at an elevation of 8000 feet above the sea; of mountain masses and ridges rising to a height of from 9000 to 11,000 feet; of wide valleys surrounded by the plateaux, at a height of 7000 feet, and of deep ravines and river-beds elevated from 4500 to 6000 feet above the sea. The plateaux are composed of sandstone overlying a formation of schistose rock, 4000 feet thick, which rests on gneiss. Grand peaks rise from the plateaux, frequently with flat tops and scarped sides. The valleys, surrounded by the steep, scarped sides of the plateaux, are tolerably well watered and yield good crops of grass and corn. One of these valleys is seen from the road leading from Senafé to Adigerat, and well illustrates some of the most striking features of Abyssinian scenery. Just as peaks rise from the surface of the plateau, so hills rise up out of the valley itself, from sides exactly like those descending from the plateau, and with flat-topped summits corresponding exactly with the plateau level. One of these *valley* hills is the *Amba* of Debra Damo, famous in Abyssinian history. The general effect of such scenery is most striking. It gives the idea of a dead level plain, which had been cut into by floods, forming ravines and valleys, but leaving portions of the plateau in their midst as islands, just as navvies leave earth-pillars to measure the depth of their excavations. The third great physical feature is the deep ravines and river-beds, which carry off the drainage, on the one hand to the Mareb, and on the other to the coast. The deepest of these gorges are towards the Red Sea, and form the magnificent scenery of the passes. On leaving Adigerat the expedition entered upon the second physical region, drained by the affluents of the Atbara, and extending to the valley of the Taccazé. The northern half, as far as Antalo, consists of sandstone and limestone, the southern half wholly of volcanic rocks. The important mountain knot of Haral ends abruptly towards the south at a point about eight miles south of Adigerat, and divides the drainage of Mareb from that of the Atbara. Looking at these mountains from the great plain of Haramat to the south, they appear like a mighty wall rising suddenly from the plain, bold sandstone cliffs with flat tops, surmounted here and there by truncated cones, with higher peaks in the interior of the mountain knot rising above them. At the southern end of the plain of Haramat the character of the country changes; there is a descent of upwards of 1500 feet, and the scenery passes from a temperate to a dry subtropical type. A broken hilly country continues thence to the great stony plain of Antalo. The country between Antalo and Magdala is a mountainous region entirely composed of volcanic rock, but it is divided into two very distinct parts by the river Taccazé. That to the north is an elevated ridge, crossed by several lofty ranges of mountains; that to the south is a plateau of still greater height, cut by ravines of enormous depth. The latter is drained by the principal affluents of the Blue Nile. South of Antalo the scenery becomes grander, the vegetation more varied and more abundant, and the supply of water more plentiful. The peculiar feature of the whole region is that, while the backbone of the mountain system runs north and south, it is crossed by ranges of great elevation running across it in the direction of the drainage and dividing it into sections. The mountainous country between Makhan and the basin of Lake Ashangi is about fourteen miles across. It is well wooded, the hill-sides being covered with junipers as tall as Scotch firs, flowering St. John's-worts growing as trees, and a heath with a white flower. The view from the southern edge of this highland is magnificent. Far below lies the bright blue lake of Ashangi, bordered by a richly-cultivated plain and surrounded by mountains on every side. The lake is without an outlet, although lying on the edge of a vast extent of country at a much lower elevation. It is some 4 miles long by 3 broad, and lies 8200 feet above the sea-level. As the water is fresh, the outlet is probably obtained by percolation at some point on the eastern side. The part of the Lasta province south of the lake is broken up into a succession of mountain spurs and deep ravines, fertile and well watered. South of the Taccazé the nature of the country again entirely changes. A mighty wall rises up, 2600 feet high, and ends in a level summit, forming the edge of the

Wadela plateau. With the exception of clumps of kosso and juniper round the churches, Wadela plain is without either trees or shrubs. The scenery is wild and desolate, not unlike that of the interior of the Orkney Islands. The Jidda river separates the Wadela from the Dalanta plateaux. The height, where the river separates them, is about 9200 feet, and it seems evident that they formed once a single mass of columnar basalt, through which the Jidda, in the course of ages, has gradually worn its way down to a depth of 3500 feet, carrying countless millions of tons of earth away to fertilize the plains of the Lower Nile. The flora on the Dalanta plateau is very English, consisting of dog-roses, the nettle, yellow and purple Compositæ, clover, and plantain. The ravine of the Bechilo, on its southern edge, is even deeper than that of the Jidda, being only 5640 feet above the sea. To the south of the Bechilo rises the Magdala system, or knot, of mountains. Magdala itself is a mass of columnar basalt, with scarped perpendicular sides, and with a plateau on the top, about two miles long by half a mile wide. It it 9050 feet above the sea-level. Besides Magdala, the system is composed of the peak of Selassie and the plateau of Fala, the three being connected by saddles at lower elevations. They are not in a line, but form an angle, of which Selassie is the apex and Magdala and Fala the two legs. The Magdala district is simply a portion of the great basaltic mass of Dalanta, which has been cut up and furrowed by the action of water during many ages, leaving the hills as isolated bits of the original plateau.

On the North-East Turkish Frontier and its Tribes.
By W. GIFFORD PALGRAVE.

The region treated of by the author was the mountainous district bordering Russian Georgia, and lying parallel to the range of the Caucasus—a journey through which he performed in the summer of 1867. The country is diversified by fertile valleys, admirably adapted for human habitation and increase. An unexpected sight met his view in these remote places—a teeming population, which had been gathered together during the last few years, and which presented signs of the formation of a new nationality. The difficulty of access to the valleys, owing to the nature of the mountain passes by which they are reached, gives them the advantages of natural fortifications, and they are well provided with all the inhabitants could require, either for successful defence or to gather forces and to issue forth against an enemy. Fifty years ago this part of the world was thinly peopled, hardly exceeding the proportion of ten or fifteen inhabitants to the square mile; at the present moment it is teeming with life, consisting of emigrant Turcoman tribes, Kurds, Georgians and Circassians; some having crossed the frontier to escape from the overwhelming tyranny of Russia, and others driven from their homes by the results of Persian anarchy. The author's journey commenced at Kars, accompanied by the Pacha and a numerous cavalcade of chieftains and their followers, who wished to manifest by this display their respect for a British official; the author's course, in a straight line, was about 140 miles, but the ground travelled over was nearly double that distance, as he diverged to the right and the left to visit the various places. The scenery throughout was most magnificent and beautiful, far surpassing anything seen in Switzerland. All the chieftains and governors in the region belong to one ruling family, which, by intermarriage with fresh arrivals, and forming an advantageous admixture of races, has continually produced men of good sense and great power in action. The intellectual and physical superiority which the men of this family display was, doubtless, due to their Georgian mothers, the chiefs having mostly married women of this race, who are still distinguished for their beauty. From every height the author crossed, new vistas were opened out of valleys dotted with flourishing villages full of new white houses, surrounded generally with a ring of gardens and a much wider circle of outer cultivation. One Pasha told the author that in his father's time there were fifteen villages; they now numbered eighty-three, some with twenty, some with sixty, and some with two hundred houses. He also explained whence the population came. The Turcomans, whose country has been conquered by the Russians, are discontented with the Russian Govern-

ment, and are continually on the look-out for opportunities to settle elsewhere. Agents were employed to let these people know that if they would come and settle within the Turkish territory they would receive grants of land and assistance to build their houses, with the enjoyment of full civil and religious liberty. The consequence was, that every year an average of about 5000 individuals of this character cross the frontier. The Russians are also driving out the warlike Circassians, who, under Schamyl, so long resisted their forces, and along with them a large number of entirely peaceful Circassians, by the vexatious and arbitrary arrangements to which they are exposed. These people all seek a refuge in Turkey, and are located in the Mount Ararat district. Besides these the lands are further colonized by Kurdish tribes, driven out of their own country by the anarchial state of Persia. These people, who are herdsmen, and prefer a pastoral life, find a new home in these rich pastures. All these men of different races are not only nobles and peasants, they are soldiers, all animated by a common spirit in favour of an Asiatic nationality—a spirit which has been aroused by the sense of a common danger, and which supplies a common bond of union. The ruling family of the incipient nationality was generally known as that of the Trebizondes, from the circumstance that its founder was appointed Governor of Trebizond in the time of Mohammed the Second. Speculating upon the prospects of this new people, the author said they might remain united with the Ottoman Empire, and become an effectual barrier to the further encroachments of Russia, or they might form an independent nationality, and, as our allies and friends, help to develope the great means of communication between Europe and India by the valley of the Euphrates and Tigris, of which they hold the key.

Description of Hong Kong. *By* GRANVILLE SHARP.

On the Uigurs. *By* Prof. A. VÁMBÉRY.

The Uigurs are the most ancient of the Turkish tribes, and formerly inhabited a part of Chinese Tartary, which is now occupied by a mixed population of Turks, Mongols, and Kalmucks. They were the first who reduced the Turkish language to writing, borrowing the characters from the Nestorian Christians, who came to their country as early as the fourth century of our era. The manuscripts of this language, written in the characters mentioned, afford, therefore, the most ancient and valuable data in investigating the history of Central Asia—nay of the whole Turkish race. But these monuments are of great scarcity; the author believed he had collected all that had been discovered of the Uigur language. It was an interesting fact that the Uigurs had a literature, and were very fond of books, at a time when our western world was involved in ignorance and barbarism. The most valuable manuscript the author had obtained bore the date of 1069, and was written in Kashgar; it treats of ethics and political subjects, and forms a kind of manual of advice to kings how to govern with justice and success. It reveals to us the social condition of this interesting people, and forms, so to say, the basis of the later regulations by which all Turks are governed. The author, having completed last year his 'Philological Researches in the Turkish of Central Asia,' was now about to publish a treatise on 'Uigur Linguistic Monuments,' which would contain more of the remains of Uigur literature than had hitherto been made known. He intended also to show that the Tartars of ancient times were not such barbarians as they now are, and that their civilization was earlier than that of the West.

Overland Route through British North America. *By* A. WADDINGTON.

The author had devoted several years in British Columbia to the exploration by himself and his agents of the various routes through the Cascade and Rocky Mountain ranges, with a view to discovering the best line for an overland route extending from Canada to the coast of the Pacific. The author believed that he

had satisfactorily solved this question, and that a practicable line, even for a railroad, had been found to exist from the plains of the Saskatchewan through Yellow Head Pass and across the central plain of British Columbia to Bute Inlet. The latter, which penetrates the coast about 100 miles to the north-west of the Frazer River, had moreover the advantage of possessing a fine and secure harbour, and of being accessible to vessels all the year round. The author pressed the great practical importance of this subject, owing to the approaching completion of the great Pacific Railroad through the United States, which would lead to the transfer of the China and Eastern trade from Europe to the New World, whilst at the same time a shorter and a better route through British territory could be shown to exist. The result of the author's geographical investigations was to prove that the physical difficulties standing in the way of a railroad-undertaking through British ground were not of great magnitude. It had, in the first place, been hitherto generally believed that the country north of Lake Superior was broken and barren in the extreme, thus rendering it totally unfit to serve for an overland communication with the West; so that the only feasible road to connect Canada with the north-west territory and the Pacific must be through Minnesota. But the explorations which were made last year by the Canadian Government showed that a vast tract of level country lies to the north of the hills which surround Lake Superior, and that good crops of wheat are raised in this region, in lat. 49°. From Ottawa to the mouth of the Montreal river, 280 miles, the country presents no serious obstacle. The ground hence to within a distance of 280 miles of the River Nipigon, in long. 88° 25′, was found to be "most favourable." Further west there is a considerable amount of sterile country; but beyond the Lake of the Woods commences the great plain of the Saskatchewan, which extends to the foot of the Rocky Mountains, and presents one thousand miles of easy ground for the construction of a railway, besides possessing a fine climate and a fertile soil. Unlike the arid American desert further south, through which the Pacific Railroad of the United States has to pass, the British line would pass over one of the richest countries in the world, and one of the best adapted for settlement. The most practicable and suitable line for crossing the mountains was the northern route, by the Yellow Head Pass and over the Cailcoaten Plain, which led to the road explored and opened by the author to the Pacific port at the head of Bute Inlet. Thus the road throughout lay at a considerable distance from the United States boundary. The distance across the continent, from Montreal to Bute Inlet, by this line was almost exactly 3000 miles, whilst the distance from New York to San Francisco by the Pacific Railroad was 3230 miles. In winter, when access to Montreal by the St. Lawrence is prevented by the ice, the starting-point would be Shippigan, which would reverse the difference by 359 miles in favour of New York. The whole country, from Ottawa to the Rocky Mountains, along which the proposed railway would run, is fertile, and fit for settlement, except some portions of the interval of 285 miles between the Nipigon and Winipeg rivers, which are composed of Silurian rocks, and are comparatively sterile. The difficulties in regard to climate are not so great as they have been supposed to be. As a general rule, railway trains run regularly all winter, with the exception of an occasional snow-storm; and further to the west the quantity of snow in winter diminishes with the decrease of atmospheric moisture. On the plain of the Saskatchewan snow does not pack more than 14 inches thick, and evaporates quickly. The isothermal lines, indeed, in crossing the North American continent, curve northwards towards the Pacific coast, and show an increase in mean temperature over the Atlantic coast equal to 11° of latitude. At Victoria, in Vancouver's Island, snow rarely falls, and the *Arbutus* grows in the open air to the size of a tree, the climate resembling that of Nantes in France, owing to the direction of the trade-winds in the Northern Pacific. Vancouver's Island lies nearer Eastern Asia, at least to sailing-vessels, than California; for, according to Capt. Maury, "the trade-winds place Vancouver's Island on the wayside of the road from China and Japan to San Francisco so completely, that a vessel trading under canvas to the latter place would take the same route as if she were bound to Vancouver's Island; so that all return cargoes would naturally come there, in order to save two or three weeks, besides risk and expense." The author concluded

by stating that the best and easiest line of communication to the Pacific across the North American continent was through British territory.

Explorations in Greenland. *By* EDWARD WHYMPER.

On the Seychelles Islands. *By* Prof. E. PERCEVAL WRIGHT, *M.D., F.L.S.*

The Seychelles group lie in the Indian Ocean, about 950 miles from Mauritius, and about 340 from Madagascar, which may be considered the nearest land; they are thirty in number, and from their productions, which the author went out last year to investigate, possess a great deal of interest. The group was probably discovered by Vasco de Gama as early as 1502. Capt. Picault in 1742 landed on the largest island and took possession of the group in the name of France. Their present name was given subsequently in honour of a French official, the Viscount Hérault de Seychelles. At the time of the French Revolution, and at different periods after it, the French made use of the islands for transporting to them political offenders; and thus members of the noblest and best families of France found themselves left on their shores, with a grant of land and but little else to depend upon. In course of time many of them were married to black slaves imported from Mozambique; and it may be said that French gentlemen with their black consorts laid the foundation of the present population of these islands. Under the governorship of the Chevalier de Quincey in 1794 the Seychelles were surrendered to the English Commodore Newcome, under threat of bombardment of the chief town. At present the islands are in charge of a Civil Commissioner, dependent on the government of Mauritius. The largest of the group is Mahé, about 18 miles long and 7 miles broad; the second in size is Praslin, about two-thirds the area of Mahé. The chief town is Port Victoria, situated in a beautiful bay, land-locked, but with two entrances quite safe, not only for the large steamers of the *Messageries Impériales*, but for some of the largest ships of war which have as yet formed part of the slave-trade squadrons in those seas. Although lying out of the reach of the hurricanes that devastate the southern shores of India and Mauritius, the islands were once visited by a most destructive typhoon. It rained for five consecutive days; at the end of the fourth day a great storm arose, and a landslip, 300 feet in width, rushed down the precipitous sides of the principal mountain, carrying down everything on its surface. Blocks of granite fifty and sixty tons in weight rolled down in the vast avalanche, destroying almost the whole town of Victoria. The town was restored under the superintendence of the present Commissioner, Mr. Swinburne Ward, and has now a very handsome appearance. The houses are nearly all built of coral and roofed with wood. At the last census the population of the whole group numbered about 7500. The temperature during the cold season averages 83° F. (28°·3 C.) during the day and 75° F. ($23\frac{8}{9}$° C.) at night. The climate is excellent, and the heat scarcely ever disagreeable. The only serious disease is leprosy; one of the smaller islands is, perhaps, the only station under the British Crown that has a leprosy establishment. This island, called *Curieuse*, is also the home and centre of one of the most remarkable vegetable productions of the world, namely, the lofty palm-tree which produces the double cocoa-nut. The language spoken in Seychelles is French, but very curiously corrupted among the lower classes of the population. There would appear to be no grammar, no tenses to the verbs, and no declensions to the pronouns. There is no phrase more common than "moi ne cont pas," for *I do not know*. Many words are lengthened by the intercalation of vowels: thus, "gelisser" for *glisser*, "belouse" for *blouse*, &c. To trace the process of this remarkable deterioration would be a curious philological study; for we know that the language was three generations ago spoken in perfect purity by the original French settlers. The highest mountain in Mahé rises to a height of from 3500 to 4000 feet. With the exception of a few porphyritic veins, the islands may be said geologically to consist of nothing but the remains of a large chain of granitic mountains, which are clothed up to the summit with tropical vegetation. The coral reefs lie generally at some distance from the shore. It is evident that the land is gradually subsiding. Looking at the land from the sea, there are two well-marked

zones of vegetation encircling the slopes. The lower one consists of an enormous assemblage of tropical plants, including dense groves of cocoa-nut palm, which form the wealth of the islanders, £20,000 worth of the oil having been exported in 1866. Manihot, rice, cinnamon, banana, the bread-fruit tree, and pine-apple are cultivated in the lower zone. The birds of the Seychelles have been recently collected by Mr. Edward Newton, and found to offer several peculiar species. Magnificent displays of phosphorescent light are observed at times by night in the sea off the harbour of Victoria. On one occasion, when the author was out in a boat at night, two white clouds of light were seen coming along the surface of the water; the boatmen were alarmed at the extraordinary appearance, but on dashing into the midst the clouds broke up into a number of large white sheets of light : t phenomenon was caused by a species of mullet of gregarious habits; countless thousands were seen, each fish gleaming with phosphorescence on its scales.

ECONOMIC SCIENCE AND STATISTICS.

Address by Samuel Brown, *F.S.S., President of the Institute of Actuaries, President of the Section.*

In the able and eloquent addresses which have been given in preceding years at the opening of this Section, the nature and objects of the divisions of science in which we are more especially concerned have been so clearly pointed out, that I do not propose to occupy your time with definitions and reflections, but rather to take a hasty view of the principal questions which, since our last Meeting, have come prominently before the public, and which are likely more especially to interest the students of our science.

Whether under the head of Economic Science or Statistics, the range of subjects is so wide, the interest so intense, and their importance to the public so vast, that it is almost as difficult to select, as it would be to confine within proper limits the full history of the past year. Thought is so busy, and civilization (if we may use the term generally to indicate an improvement in the social condition of nations) advancing with such rapidity, that new subjects are continually thrusting themselves into notice and discussion by the different classes whom they most affect. It is essential, however, to make choice of a few leading features, and one topic which has during the past year, and is now exciting a very lively interest, is that of technical education.

Technical Education.—A very strong impulse has been given to the discussion of this question by the various comparisons of the world's industry, which, ever since the Great Exhibition of 1851, the success of which was so much owing to the far-seeing intellect and earnest purpose of the lamented Prince Consort, have enabled all nations to measure their respective progress in science and art, by the actual results of their manufactures and industries in every branch. Many persons have expressed alarm lest other nations which have discovered their deficiencies, and have set to work with energy and determination to remove them, should leave this country behind in their applications of knowledge, by introducing and maintaining a more practical, if not a higher standard of general education amongst the people. Without going too far back to the frequent discussions to which this subject has given rise, it will be sufficient to refer to the Report of the Committee appointed by this Association to consider the best means for promoting scientific education in schools, which was presented at the last Meeting at Nottingham. The Committee admit the existence of a general and even national desire to facilitate the acquisition of some scientific knowledge by boys at our public and other schools; and a very interesting account is appended of the progress which has already been made in Oxford, Cambridge, the University of London, and the College of Preceptors, as compared with the French and German schools. The conclusions of the report are highly practical, and recommend that in all schools natural science should be taught; that at least three hours a week should be devoted to

such scientific instruction; that as to honours and prizes, it should be placed on an equal footing with mathematics and modern languages; that universities and colleges should be invited to make it a subject of examination, and that the importance of appointing lecturers, and offering entrance scholarships, exhibitions, and fellowships, should be represented to the authorities of colleges.

No mention is here made of the extent to which, or the mode by which, the Government might be called upon to aid in improving the technical education of the country. In the early part of this year, however, a conference, called by the Society of Arts, brought together a great number of the most eminent statesmen, men of science, teachers, and representatives of manufactures and commerce, by whom this important subject was for two days discussed under all its varied aspects. It would be invidious to mention names, when nearly all the distinguished thinkers who have so long worked for the educational improvement of the people contributed their part to the discussion. The resolutions were general, giving only the broad outlines of the opinion of the meeting, as it was intended to appoint a subcommittee to carefully examine and report on the details.

The report of the Committee, which was not delivered in till the 21st of July last, states that the conclusions they had arrived at were in substance, that technical education, as referred to them, excludes the manual instruction in art given in the workshop, rather meaning general instruction in those sciences the principles of which are applicable to the various employments of life. It should be given, not in separate professional institutions, but in those for general education. It is desirable that schools should be established, having for their main object the teaching of science as a mental discipline. It is necessary to introduce scientific teaching in all secondary schools. The higher scientific instruction should be tested by public examinations, and the proficiency of the students certified by diplomas. In detailing the course of instruction for certain businesses, such as agriculture and gardening, chemical manufactures, metallurgy, mining, civil engineering, mercantile marine, that of the naval architect and marine engineer, the mechanical engineer and machinist, the architect, and the merchant, the scientific instruction should be followed by practical pupilage in efficient workshops or establishments. A great advance in technical education might be expected, if the employers of labour would generally give the preference to those who produce evidence of having been adequately instructed in the sciences applicable to their particular occupations.

These are practical suggestions, but the question itself opens up nearly all the points or theories to which the discussion of the general education of a people has given rise. Is it to be expected that ignorance would seek for instruction of its own accord? If scientific instruction is to be brought down to the lower class of labourers, by what means shall the parent who prefers utilizing the manual labour of his child at an early age, be compelled to spare him for the higher duty of instruction in order that he may be enabled to earn more for himself hereafter?

It seems admitted that if better instruction is given in the secondary schools, it must also be improved in the primary, as there is evidence to show that there is little disposition in scholars to take to the higher class of learning without having received the elements of it at least in the earlier stage. It is also proposed that children should remain longer at school. How will this affect the labour market, and will the greater skill acquired compensate for the delay?

The attempts which have been hitherto made to bring lectures and laboratories within reach of the working classes, do not appear to have been very successful, nor, as a general rule, do the employers of labour, who, we should imagine, would most benefit by the increased intelligence of their workmen in their special art, give much encouragement to the efforts of those who have so patriotically devoted themselves to this object. In Cornwall the Mining Institution failed in its expected effects by the original defective education of the working classes, who, unable to read easily, or to take notes, or to do the simple arithmetic required for the calculation of the percentage of ores, soon grew tired of lectures they could not follow with interest. Professor Huxley points out that the School of Mines in Jermyn Street was not established by the mining interests, but by the eminent geologist, Sir H. De la Beche, and that very few pupils attended until recently,

when, by the offer of pecuniary rewards and medals, and the prospect of appointments hereafter, 600 or 700 average papers were sent in for competition in some branches of science, and 1200 or 1300 in chemistry. This seems to indicate the right method by which the friends of technical education might stimulate the classes to whom the higher rewards are not accessible. Associations might be formed, so that in the various branches of study the united subscriptions would allow of studentships being given, tenable for three or four years. By these means the young workman, or even one more advanced in life, may not only gain the reward of his ability, but obtain some compensation for the diminished wages which may temporarily follow the giving up a portion of his time to increase his skill hereafter. The employers of labour of all kinds, but especially those in which the higher ability required renders a considerable premium only a fair price for admission to the business, might tempt many from the overcrowded professions by a judicious offer of remitting the premiums where high distinction has been gained. Probably the cost to themselves would be in many cases soon more than compensated by the higher theoretical knowledge brought earlier into use.

In connexion with this subject, it is impossible not to feel that the munificent gift of Mr. Whitworth deserves the heartfelt gratitude of the nation. What effects will be produced by thirty scholarships of the annual value of £100 each, in a single branch of applied science so important to this country as engineering, and mechanical industry, it is difficult to calculate. Not merely the succession of new aspirants every three years, but the numbers who, though falling a little short of the splendid prize, will yet have given all their powers of mind to obtain it, may be expected to create an impulse and maintain a mental activity which will not allow England to fall behind in her continental rivalship. It is not to be expected that many individuals can offer singly so noble and patriotic a gift, but they may combine together, and thus, by the union of isolated efforts, institute similar rewards for proficiency in other arts or occupations. That there is amongst our industrial classes a large number of intelligent and skilled workmen, with ability to compete for similar prizes, may be seen in the admirable volume of reports of the artisans selected by the Society of Arts to visit the Paris Exhibition, and published by the Society. The deep knowledge of their particular industry, the general keenness of observation, the common sense, and in many cases talented style of writing, besides the variety of the contents, make it a volume of remarkable interest, highly creditable to the class from whom they were selected.

In the higher branches of science, the universities, colleges, and great schools, with their wealthy endowments, will be called upon to move with the times; and there are signs of their already preparing to respond in a suitable manner to the voice of the nation. The offer of fellowships, scholarships, and exhibitions may be made to suit all grades of scientific requirements. Though it may sensibly diminish the number of classical rewards, it is probable that it would not really lower the high standard of classical excellence in the country, whilst it would raise up a fresh career in which renown may be won. Many who by other inclinations may not be the first in classical studies, may achieve a world-wide fame for the university or college of their choice, by their attainments in science instead.

In what manner the Government may best be able to second the efforts of the friends of education is as yet undecided. Some suggest that they should establish secondary or higher schools in the locality of a particular industry, and adapt the teaching to the special wants of the population around. But the question arises, are these schools to be founded in places where no special desire is felt for the higher instruction offered, or in other places where the voluntary efforts, either of the masters or workmen, or both, only require additional aid to render them effective? It may be said that the former need it most; for how are we to overcome ignorance or apathy, if the State will not be at the expense of exciting at least a desire for improvement, and teaching the people the advantages and pleasures of knowledge. On the other hand, are those who have proved their earnestness by pecuniary sacrifices to be left to struggle on feebly, whilst others who are indifferent to scientific education have it brought to their doors? Others, again, consider that schools for special science, at any rate for the labouring classes, have gene-

rally failed of success, and that the best plan is to improve education generally, giving it a higher tone, both in the primary and secondary schools, and making science more a part of the general study, but with special application of it for the pupils of more advanced ages.

The evidence in the Report of the Select Committee of the House of Commons on the subject, which has recently appeared, gives an encouraging view of the practical skill of our workmen in nearly all branches of industry, leaving no reason to fear the rivalry of foreigners in mere handicraft. But the competition in commerce and manufactures is so close in the markets of the world, that the superior technical education of the continental workman, enabling him to adopt so readily any new processes or improvements, gives him manifest advantages over the English workman. It is essential for our industrial classes to be better instructed in science and its applications, and be less liable to fail by clumsy inventions and costly errors.

On the whole it would seem that the action of the Government will be most beneficially exerted in the first instance by extending the system of grants in aid of local exertions, by adding to the emoluments of teachers who produce evidence of the higher class of instruction having been efficiently imparted, and by aiding in the cost of building where new schools of a special scientific character are needed. Above all, the stimulus of endowments or exhibitions of adequate value, or the offer of Government appointments in such departments as science can be most usefully applied in, will probably produce the most profitable results for a national expenditure.

Labour and Capital.—Another subject, vitally connected with maintaining the position of this country in its competition abroad, as well as with its peace and prosperity at home, is the relation of wages to capital. For many years the most violent discussion has been going on; but it really appears as if some progress has been made during the past year in an amicable solution of the difficulty. The opinion that labour and capital must be in antagonism, each trying to subdue the other to its own terms—an opinion which can only be entertained in complete ignorance of their relative functions—is becoming gradually undermined, and the earnest efforts of some of the most practical and enlightened employers of labour, aided by the increased intelligence and better feeling produced by conciliation on the working classes, have allowed some important experiments to be fairly tried to reconcile the two opposing foes, and to bring them into harmonious working together. It is true the beginning is feeble, and what is accomplished small, compared with what remains to be done. It is now generally admitted that a better knowledge of the principles of political economy, and of the laws which regulate wages and capital, the production and distribution of wealth, would be beneficial to all parties. A most influential general committee has been formed under the auspices of the National Association for the Promotion of Social Science. In an evening meeting, at which the Right Hon. W. E. Gladstone presided, the question was debated, and certain general principles laid down for the course of proceeding. But the work to be accomplished is of the most laborious character. The mass of prejudice to be overcome on both sides is the growth of years, and it yet remains to be seen how the interference of a third party, though professing to represent impartially the interests of the public and the true principles of economic science, will be received by either. It is to be hoped, at any rate, that the clumsy and barbarous system of strikes and locks-out, which destroy both the small savings of the workmen and the capital out of which he hopes to increase his wages, and which keep up a perpetual source of irritation and ill-feeling, will be abolished as an insensate and reckless process. Trades' Unions are contended for by some as useful and effective, if not carried on to the injury of the trade, or to the detriment of the nation, and provided the members pursue their own objects without undue coercion of others. But without coercion and oppression how can they fulfil their objects? The limitation of times of labour, the depression of the sober, industrious, and most skilful workman to an average level of the more idle and unskilful, the exclusion of apprentices, and the dire effects in other branches of the trade or manufacture in which, without wishing to strike themselves, the workmen are dependent on the continued labour of others, who will not work, naturally drive capital away into

other countries or other trades, and thus leave the infatuated workman with worse prospects of success than when he began the strike. Nor can we pass over the selfishness with which one branch of occupation frequently pursues this system of strikes without reference to others, who, though unwilling to throw up their employments, are forced into unprofitable idleness, misery and want, that other classes may better themselves by higher wages. The whole of this false and dangerous system must be superseded by some other scheme or schemes which will unite in harmonious working labour and capital. It is not necessary that there should be but one remedy. The excesses of the working classes of France in the Revolution of 1848, and their vote to expel the English workmen, led to the indignant remonstrances of the French political economists, and eventually to the institution of the Conseil des Prud'hommes, courts of arbitration, and industrial partnerships, which have had the happiest effects. In France, in the ten years 1830–40, Mr. Mundella informs us the courts of arbitration have adjudicated on 135,730 cases, of which 128,319 were amicably settled, 3530 withdrawn by consent, 3881 judgments pronounced, from which there were only 155 appeals. In Nottingham especially, according to the testimony of Mr. Mundella, the working of the Board for seven years up to the present time, has been most favourable, and in the highest degree satisfactory both to the employers and the employed. The Board consists of an equal number of masters and workmen on each side, with a president chosen by consent, and for three years and a half they have been enabled to agree on all points in debate without the necessity of coming to a vote. The system has recently been extended to Hawick, North Britain, and to the Potteries. The Council of the Amalgamated Trades Unions passed a resolution, desiring the establishment of these Boards in all branches of their Union; and there seems little doubt that the courteous and kindly meeting together to settle in common questions which were formerly sources of hostility and irritation, would, if introduced in all trades, have a wonderful effect in uniting two classes so essentially necessary to each other as the capitalist and the labourer.

But there appears to be even a more powerful mode of cooperation, because it appeals more directly to the self-interest of the working classes, viz. industrial partnerships, in which the masters and workmen may unite together. Cooperative stores imply a combination of consumers to cheapen the price of articles purchased, but their tendency is naturally to dispense with the class of dealers or middlemen, and by the saving of the profits formerly gained by them, the consumers benefit at the cost only of the relatively small expenses of managing the stores. But what would become of the class of dealers or tradesmen, if this principle was generally acted upon? In admitting the workmen into partnerships of production, the greater part of the difficulties between labour and production seem to vanish. As every one of the partners is interested in increasing the profits, he can have no wish to stint his own labour, or to check in any way the labour of others. He not only is careful not to waste the materials himself, but he keeps a vigilant eye that his fellow workmen may be equally careful. He is led to understand the accounts of a firm, and the causes of depression and prosperity of trade. Strikes frequently occurred when from the closeness of foreign competition the market could least bear them; the workman, when a partner, sees that at such times his profits would be diminished by any check to, or increased price of labour.

The most remarkable and encouraging example of the new system was given in a aper by Mr. Briggs, read before the Social Science Committee of May last on the Whitworth collieries. In ten years there had been four strikes, involving cessation of work for seventy-eight weeks. During the whole of that period the annoyance and anxiety of the partners were extreme. The profits were reduced to little more than 5 per cent. on their invested capital. They were compelled to evict families from their cottages, in order to introduce new labourers for their works. The police were required in large numbers for the protection of the non-union men. At last the painful struggle terminated in a riot in the village, the ringleaders of which were convicted at the York Assizes in 1863. But in 1864 the proprietors determined to take the whole of the men into partnership, and a limited liability company was formed from 1st July, 1865, of which they retained two-thirds of the capital, the remainder being allotted in shares to be pur-

chased by the men. After paying a moderate rate for wages and management, and the proper allowance for reserves and depreciation, any excess over 10 per cent. of the profits was to be allotted half to the capital, and the other half as a bonus to the workmen in proportion to their earnings. At first they were suspicious, but the plan succeeded so well, that in the very first year the dividend was 12 per cent., and the 2 per cent. which was allotted as a bonus on wages, allowed of an average increase $7\frac{1}{2}$ per cent. to the work-people on their earnings. In the second year, 80 per cent. of the workmen took shares; the profits were 13 per cent., and the 3 per cent. bonus allowed an average increase of 10 per cent. on the workmen's earnings, besides setting by 9 per cent. on the capital as a reserve fund. The village has been perfectly peaceful, the work-people have become sober, industrious, and respectable in their conduct, and they generally invest their profits in the extension of the business. There has been no dispute and no charge of neglect of work made. This is not a small experiment, 1200 men and boys have benefited by the operation, and £90,000 of capital is invested in the concern.

With modifications adapted to different trades, this system seems worthy of a wide extension. The proper rate of bonus for labour must, no doubt, depend on the proportion which the labour bears to the other costs of production and of bringing the article to market. Competition of foreign countries, variations in supply and demand, may prevent wages bearing a fixed proportion to the other capital required, consequently the bonus to wages may have to be adjusted in different manufactures or trades. But some of the best of the trades' unions have declared themselves in favour of the trial of this scheme, and the commercial greatness of England is deeply interested in its success.

Insurance.—Leaving subjects still so full of doubts and difficulties, we turn to one which, though established upon laws of nature equally recondite, has been pushed into practice with an energy and success highly creditable to this country. It would be inexcusable in this city (in which have been founded two amongst the greatest and most enterprising of our insurance companies, which under the able management of Sir Samuel Bignold, one of the Vice-Presidents of this Section, have obtained so wide a reputation, and to whose representative in London, Mr. C. J. Bunyon, we are indebted for the best works which have appeared on the law of fire and life assurance) not to allude to the progress which these valuable institutions have made in this country. Vital statistics are now assuming a form which enable the most complicated problems of human life to be dealt with as if they were certain and simple events. Yet little more than a century has elapsed since the Attorney- and Solicitor-General of that day, when reporting on the application for a Royal Charter to the first society formed on scientific principles for the assurance of life, objected to it on the ground that its success must depend on calculations taken on tables of life and death, whereby the chance of mortality is attempted to be reduced to a certain standard. "This is a mere speculation," they observe, "never yet tried in practice, and consequently subject, like all other experiments, to various chances in the execution." Further, considering that the general tables include both healthy and unhealthy lives, they thought that "the register of life and death ought to be confined, if possible, for the sake of exactness, to such persons only as are the objects of insurance." It was argued, to show the small probability of success for the society, that the Royal Exchange Assurance, in forty years, had taken only £10,915 in premiums, of which the profits, amounting to only £2651, must have been nearly exhausted in the charges of management. They would hardly expect a more considerable capital to arise from lower premiums, and the hazard of loss will be increased in proportion as the dealing will be more extensive. The petition was dismissed, but the Society (the Equitable) was formed, and in spite of the gloomy prognostications at its birth, had afterwards, at one time, nearly £20,000,000 of assurances on lives in force together. About six years back, from an estimate made on a large proportion of the companies in the United Kingdom, it was computed that about £372,000,000 were assured upon lives; and at the rate of progress made of late years, it is probable that this is now increased to £400,000,000. But a still more remarkable extension of this kind of business has, within a few years, taken place within the United States of America. At the close of 1866, thirty-nine companies doing business in the State of New York, had about

305,390 life policies in force for upwards of £173,000,000, which at the end of 1867 had increased to 403,841 policies for £233,400,000. A single company, the Mutual of New York, had issued in that one year 19,406 policies for £12,450,000, taking in new premiums upwards of £801,000. The assurances in that Company alone amounted to nearly £39,000,000, being almost three times the amount at present existing in our largest office in this country.

Considering the great pecuniary interests at stake, the discovery of the true law of mortality is of deep importance. The theory of that eminent mathematician, Benjamin Gompertz, F.R.S., that there is in the human frame a power to oppose destruction, which loses equal proportions in equal times, and consequently that the intensity of mortality is represented by a series in geometrical progression, was founded upon actual observations of numerous tables. Such a theory is congruous with many natural effects, as, for instance, the exhaustions of the receiver of an air-pump by strokes repeated at equal intervals of time, and it has been confirmed for long periods of life in most of the tables of original observations which have been made. There is a marked difference, however, in the constants of mortality in three principal periods of life, childhood, manhood, and old age. There are also exceptional or climacteric years of life, and from the variety of circumstances which may effect health or life, such as occupation, locality, habits, exposure to disease, &c., so many peculiarities in each class of observations, which themselves may have been incorrectly or imperfectly collected, that it is very difficult to detect in any what may be called the true or universal law of mortality.

A very important inquiry is now being made, under the auspices of the Institute of Actuaries, into the actual experience of some of the older companies. The facts relating to 147,000 persons admitted after medical examination as healthy lives, of whom about 24,000 had died, afford ample materials for many interesting deductions in vital statistics, and are especially valuable for the accuracy of the records. A similar investigation is being made in Germany and in the United States of America, conducted by scientific institutions of a like character, and by some of the leading mathematicians of those countries.

It is to be regretted that no authentic information as to the total amounts insured in various branches is known in this country. In fire insurance a rough estimate, deduced from the duty, would give about £1,445,000,000 in 1867, including nearly £80,000,000 on farming stock. The total amount of marine insurance business is equally uncertain, though it must be increasing with the rapid strides of commercial enterprise. Mr. Morris Black, in his analysis of the accounts of marine insurance companies established since 1859, gives the premiums received by eleven of these companies in 1867 as nearly £2,800,000, insuring about £227,000,000; but this does not include the five oldest and largest companies, nor the great amount underwritten by the members of Lloyd's. The total value of shipping and commercial products liable to risk in voyages between different ports would be the more interesting, as the Statistical Committee of Lloyd's have for the last two years, by the aid of their honorary secretary, Mr. Jeula, collected and compared some of the most striking results of the accidents and losses in which, as a great maritime nation, we take so great a share. In 10,587 vessels in 1866, to which accidents of some kind happened, and 11,424 vessels in 1867, the accidents of different kinds, whether sailing vessels or steamers (the latter being about 10 per cent. of the total), show a remarkable regularity in the percentage, and indicate the value of a more extended inquiry. The tables comprise losses and casualties in all parts of the world, and are divided into thirty-one geographical sections, for the voyages between the ports in each section. With these and the annual wreck registers of the Board of Trade for the dangers nearer our own coasts, and fuller statistics from our own and foreign countries, on a uniform plan, of the amount and value of shipping and cargoes passing from port to port in different trades, we may expect a great increase in our general knowledge on these subjects.

At the Statistical Congresses held in Paris in 1855, and at Berlin in 1863, it was recommended to collect the statistics of all branches of insurance, in such a form that the progress of nations therein might be compared. The heads of the Government Statistical Departments of several countries are now engaged in maturing a plan for comprehending these and other commercial statistics in a full report.

Electric Telegraphs.—One of the most important aids to the social and commercial progress of any country, is the facility in the means of personal intercourse, and especially of frequent communications by post and verbal messages. Good roads and railroads, giving rapid and cheap means of transport both for passengers and goods, are essential to the increase of internal trade. But equally essential is the power of sending swift and accurate messages, and receiving prompt and correct replies. The annual extension of the postal and telegraph system is a striking proof of the mental activity and growth of the internal trade of the country. In 1867 the letters delivered had reached nearly 775,000,000 in the United Kingdom (being $3\frac{1}{3}$ per cent. excess on the previous year, and averaging 144 letters to each inhabited house). The book packets were more than 102,000,000, being an increase of one-half per cent. on the previous year. The receptacles for letters were 17,225, being 1 to every 312 inhabited houses.

Whoever originated the idea of the penny post, the nation will always feel that it is to the ability, the energy, and the perseverance of Sir Rowland Hill that we are indebted for the inestimable benefits which have followed the realization of the idea. In the history of the progress of the age his name will be always conspicuous.

The success of the Post Office, and the enlightened readiness with which every improvement is adopted and the wants of the public supplied, give us reason to hope that what many regard as a very questionable interference with private enterprise, in the proposed purchase of the telegraph property of the whole kingdom, in order to place it under one management, will prove eminently for the public benefit. The facilities possessed by the Post Office in having money-order officers and employées who, at a very slight additional expense, may work the telegraph in localities in which it would scarcely pay profits to the companies to form new stations, are likely to create and satisfy the demand for numerous extensions. In populous places, from which the profits are mostly now derived (it is stated that 75 per cent. of the entire receipts are from fifteen towns, and one-half from London), the combination of the pillar-post and stamped paper for telegraphs in the suburbs, the saving of extra charge for distances in the delivery, and all over the country a uniform and cheap rate, will no doubt lead to an immense development of the system. It is highly probable that in a short time a uniform charge of 6*d*. a message of a certain length will be established. The consequence will be felt as well in the convenience of private intercourse, as in the internal trade of the country in bringing distant markets together, and, by increasing the competition, obtaining a greater approach to equalization of prices for the great benefit of the public. It is assumed that the number of telegraph messages is increasing at the rate of 10 per cent. per annum, and that on the 1st July, 1869, the Government will start with the estimated number of 7,500,000. Supposing that present charges of £65,000 a-year may be saved by amalgamation of all the lines, and allowing for various costs, for extension, &c., a maximum net revenue of £358,000, or minimum of £203,000 per annum is Mr. Scudamore's calculation, with which Government credit would more than raise the capital of £6,000,000 required for the purchase. But it is scarcely possible that with so many interests, still to be settled by arbitration before the money-bill can be brought in in the next Parliament, that even this large sum will suffice to complete the purchase. There is nothing to prevent the Government competing, if the public interest required it, without laying out so large a sum for the purchase of interests which are not vested. But besides the natural feeling of the public against the unfairness of destroying, and the risk of discouraging, private enterprises which have produced, or are calculated to produce, such good results for the country, there is no doubt that the machinery and arrangements already complete, and the facilities afforded by the railway leases, form a basis for immediate improvements which will so much the earlier repay the outlay. The other objections, that Government may use the lines for favouritism or for political purposes, that they would have the command of all the secrets of private individuals, as well as those of their public opponents, that they might harass the press by delays, or transmit news to one journal to the exclusion of another, appear either to excite no alarm, or to have been met, as in the last case, by a judicious compromise, and the formation of a

company to collect news for themselves. On the whole, there seems reason to hope that this great experiment may be tried in the course of next year, and that no fresh agreement with the companies, which would be still more costly, will be rendered necessary by delay.

Conference on Weights and Measures.—During the past year there have been several important Congresses in which the British Association has been either interested or represented. The Metric Committee, which was reappointed in 1866, united its efforts to those of the International Decimal Association, to obtain a special exhibition of the weights, measures, and coins of all countries in the Paris Universal Exhibition. The Imperial Commission applied to all the Governments of Europe and America to send copies of their standards, and to appoint delegates to take part in a conference to be called for a full discussion as to the best means of obtaining a uniform system for all nations. The exhibition, which appeared to excite great interest, was held in the pavilion, in the central garden. It had the great advantage of showing, by contrast, the singular simplicity and beauty of the metric system of weights and measures as compared with all others. The Conference, at which delegates officially appointed by the governments of all the leading countries attended, was presided over with great ability, first, by M. Mathieu, Member of the Institute of France, and afterwards by His Imperial Highness Prince Napoleon; and after a full discussion on an able report prepared by Dr. Jacobi, Member of the Imperial Academy of Sciences at St. Petersburgh, it was decided to recommend the universal and sole adoption of the metric system, —not a single voice being given against it, nor a single word said in favour of any other system. Strong resolutions were unanimously passed also at the International Statistical Congress, held at Florence in October last, recommending its universal adoption, advising that Associations should be formed in all countries where it is not yet introduced, to prepare the way for it and make its advantages known, and that it should be taught in governmental schools, and used in all post offices, custom houses, and public establishments.

In this country, where the Metric Weights and Measures Act, 1864, renders the use of the system legal, the singular anomaly still exists that no provision is made for stamping and verification by the standards, and consequently parties may be liable by one Act to the usual penalties for using such weights and measures, although by another contracts made by them therein are lawful. The Act indeed is so defective, and the progress of the system so great, that another Act was introduced in the session just closed, to make it compulsory, within some given period to be fixed in committee. Mr. Ewart, together with Mr. Bazley, Mr. Baines, Mr. J. B. Smith, and Mr. Graves took charge of the Bill, and after an animated debate, the second reading was carried by the large majority of 217 to 65. It was set down for committee on 1st July, but the state of public business prevented its being proceeded with. It will be one of the questions of great, if not pressing, importance for early consideration by the new Parliament.

The first report of the Standards Commission which has just been presented, shows the necessity of the establishment of the Standards' Department, which carried out one of the recommendations of Mr. Ewart's Committee. Several indications are given of progress in the decimal system. The metre also has been laid down from the authentic metre in the possession of the Royal Society, and the kilogram verified by Professor Miller, transferred from the Royal Observatory at Greenwich, and steps have been taken to procure a complete series of the weights and capacity measures of the metric system. But as to the probable effect of its introduction into this country, the Commission have not yet had time to examine the numerous papers which have been collected, but admitting its importance, will give it their early and best attention.

In the meantime the confusion and intricacy of the weights and measures in our vast dominions in India have led to the appointment of Commissions to introduce a thorough reform. The metric system has been recommended by Colonel Strachey, F.R.S., President of the Indian Committee, as the best system for entire and exclusive adoption throughout India, and this view has been supported by two Commissions. Mr. Charles F. Gover, in a very able paper on uniform metrology for India, proves that formerly not only was the decimal system universal in India, but that the

ancient measures of land, and the original basis of the present system of linear measures, was almost identically the same as the metre—39·3 inches (for 39·37079 inches).

The only cause for delay in introducing a uniform system in India, seems to be the idea that the imperial weights and measures will still retain their position in England, and that their system must have some easy relationship with what prevails here. But the metric system is admitted to be the best, and if it should be finally adopted here, all that vast population would be exposed to the inconveniences of a second change.

In the United States of America, the metric system is permissively legalized, but more completely than in England, by the introduction of the standards for verification. The official delegates of America have declared that the United States would follow England in making the use compulsory. If England took the lead, India and all her colonies would unite with us. The system which is now legal, in whole or in part, and either compulsory or permissive, amongst 275,000,000 of people, would then comprise upwards of 450,000,000 of people using the same weights and measure, with decimal subdivisions and multiples in the simplest and most perfect form either for calculations or commercial use.

One hundred years ago such an idea might indeed seem utopian, as would also now be the notion of finding acceptance for another universal unit. But when, by peculiar circumstances, such rapid progress has been made towards uniformity, it is practical wisdom to seize every opportunity to promote it. In science, in commerce, in education, in international intercourse, in statistical inquiries, it is difficult to picture the vast benefits that would result from the adoption of one and the same unit by all civilized nations.

Monetary Conferences.—Far greater difficulties and differences of opinion lie in the way of a monetary unit of account, or even uniformity of metallic currency for the leading commercial nations; yet a great movement has been going on therein during the past year. The Conference, in connexion with the Universal Exhibition at Paris, over which Prince Napoleon presided, discussed and agreed to resolutions that the different Governments should adopt a common base or unit in the issue of their gold coins; that it should be of the same fineness, nine-tenths; and that in each country there should be one piece at least equivalent to one of the pieces in another country, so that there might be a point of contact in the currencies of all countries. The 5-franc piece in gold was finally adopted as the basis, since the multiples thereof would very nearly accord with the monetary units of several countries. M. Wolowski, the distinguished economist, defended with great eloquence and energy the double standard of silver and gold, but he found no seconder. A single gold standard, and everywhere the decimal subdivision of the unit, were carried as the nearest means of obtaining some coin everywhere current, and values easily translated into those of foreign nations.

But the International Monetary Conference, which was called about the same period in June of last year by the French Government, is likely to produce still more definite results. All the leading Governments of Europe and America sent official delegates to represent them. The basis taken by the Conference, subject to such improvements as might be suggested, was the convention concluded the 23rd December, 1865, between Switzerland, Belgium, France, and Italy, for a common currency; by Article 12 of which convention the right of accession was reserved to any State which would accept the obligations and the monetary system of the union, as far as regards the gold and silver coins. The delegates did not appear to have any authority to bind their respective Governments, except that of Austria, for whom Baron von Hock at the end of the Conference negotiated and signed a preliminary treaty of adhesion to the Convention of 1865. In the early part of 1867 the Papal Government had joined the Convention, and in April of the same year the currency of Greece was remodelled on the same system.

The French Government were anxious to obtain some definite answers to the propositions of the Congress, in order to call a new Congress with more extended powers; but no definite time was fixed for the replies, some voting for replies by the 1st October last, and Great Britain for an extension to the 1st June of this year. The report of the English delegates, Mr. Graham, Master of the Mint, and

Mr. Rivers Wilson, of the Treasury, has been referred to a Royal Commission for their opinion, whether Great Britain would be justified in making any changes in her currency which would allow in any way of her joining the Monetary Convention. This report, with the evidence taken, is anxiously expected.

It does not appear that a merely international currency of one or more coins would compensate for the trouble and inconvenience of altering, even to a slight degree (one grain is all that would be required), the quantity of pure gold in the pound sterling. But a common unit of account would offer manifold advantages. An international unit of 10 francs, which would have many advantages over 5 francs as the smallest gold coin, subdivided decimally, would at once give, in all commercial quotations, and in all statistical records, precisely the same figures. All nations who accepted it would use the same language of value, and instead of the 5, 15, and 25 francs, as suggested by the Congress, which would require constant computations in the translations of different languages, only 1, 10, or 100 would be used, in which values in every country would always be expressed in the same figures.

If pure theory were to be insisted on for all the nations adopting the metric system of weights and measures, 10 grammes of pure gold, without alloy, should be the unit of value = 34·44 francs, or very nearly £1 7*s.* 6*d.* But this would necessitate the coinage of all their gold and silver afresh, the gold alone being estimated to be £280,000,000 sterling in those States which have joined the Convention, as well as £360,000,000 in other continental States which may join it hereafter, and £60,000,000 in the United States. In Great Britain the gold coinage, though uncertain in amount, is not generally reckoned at more than £100,000,000.

We must therefore take a practical view of the proposition; and it would not be to the credit of this country, with its great influence in commerce, and its pretensions to a high place in social progress, to withdraw from conferences in which other nations are taking so active a part, in questions so likely to promote the peaceful intercourse and prosperity of all.

Statistical Congress.—The other Congress in which this Section is particularly interested, was the International Statistical Congress, which, four years after its previous meeting in Berlin, was invited by the Government of Italy to meet in Florence in the early part of October last year. The statesmen, learned professors, and social reformers of Italy formed a larger body of natives, 623, with 85 foreigners, than even the Congress in London in 1860. The King had nominated his eldest son, Prince Humbert of Savoy, as general President, and His Excellency the Minister of Agriculture, Industry, and Commerce (S. de Blasiis), took a most active part in the proceedings. The effect of these Congresses, of which six have been held since 1853, is seen in the great improvement in the form of collecting government statistics of all kinds. By uniformity of methods and principles, not only may the relative progress of nations be compared, but the phenomena of political and social economy examined under different conditions and varying aspects. Thus the law of the production and distribution of wealth, of the growth or decay of population, the causes of early or late marriages, the effects of emigration on the country left or adopted, the best means of the prevention or suppression of crime, the evil effects of great standing armies, interfering with the production, or causing wasteful consumption in a country, and numerous other questions of the highest interest to society at large, may be traced on the broad map of a continent, instead of the narrow limits of a single country.

At each successive meeting, the able and earnest men who, as government officials, really have influence to carry out the resolutions agreed to, have discussed nearly all the subjects on which national prosperity depends. The summaries of the previous reports by Dr. Engel of Berlin, and Dr. Maestri of Florence, are full of matter for reflection, laying down the principles on which every possible statistical question ought to be studied.

An attempt is now being made by some of the leading members, animated and guided by M. Quetelet, who may be considered the founder of these Congresses, to collect on a uniform plan the comparative statistics of all nations under the principal heads. The first volume, on population, was presented by M. Quetelet

at the last Congress, and is an admirable *résumé* of hundreds of scattered official volumes. It is to be followed by other compilations in different branches of statistics, showing that these meetings have not ended in idle discussions, but will assist the philosopher in his studies, as well as the practical man in his efforts to promote the social improvement of the people.

On the suggestion of M. Quetelet, a Section will be formed in the next Congress, especially to examine statistical subjects in their direct relation with the theory of probabilities. The laws of the recurrence of events will thus be eliminated, and many questions which are now obscure may, by due value being given to the weight of observations, be reduced to correct or approximate theory.

Such Congresses and meetings like the present enable all those who are engaged in a common pursuit, to benefit by the labour and skill, by the depth of thought, or wide experience of their fellow-workers in the same field. They bring the kindly feelings of friendship to the aid of scientific investigations; they allow no man to feel that he can repose, as if he had done enough for society; for he finds in the brief interval since we last met, what new questions have agitated the world, and how he must bestir himself to keep pace with the intellectual progress of the age; they point the way to unexplored tracts of knowledge; they utilize the smallest contributions of thought whilst filling the mind with suggestions of the extent and variety of the problems which still remain to be solved in the social condition of man. The domain of statistics is so vast, that we should welcome any new labourers who will cultivate the new fields of research constantly opening up. If not strictly a science, it is at least a method of investigation which requires to be conducted in a scientific manner, and in an earnest spirit of search for truth. Even undeniable facts may be so collected as to serve the cause of prejudice, to perpetuate error, or to conceal the laws which they should reveal. In social science and political economy, statistics may be considered the collection of experiments, by the results of which we observe the hidden workings of the laws which regulate the social condition of man, and his progress in civilization. The growth and decay of population, the freedom of capital, and the rights of labour, the duty of voluntary or enforced education, the extent of Government interference in labour or manufactures, the competition of prices, the true principles of commerce, the most effectual means of suppression or prevention of crime, the theory of taxation and national loans, and multitudes of similar questions are all governed by subtle laws affecting the free will of man, checked and kept in place by similar action in others, of which we catch a glimpse sometimes by their irregular action in enforced or abnormal conditions, and sometimes by our having discovered and acted in harmony with the natural law which governs them. But as society is perpetually changing, what we have discovered and thought to be truth seems frequently inadequate to account for the new phenomena presented. It is only by extending our observations from the narrow sphere of a single country or a single class to all countries and all classes, by such a uniform collection of statistics as is now being made by all the Governments of Europe, by noting differences as well as analogies, and confessing and correcting errors, and comparing the operations of the same causes under various conditions of interference, that we shall throw light on the many unsolved problems of social and political economy which modern civilization presents.

On some supposed Differences in the Minds of Men and Women with regard to Educational Necessities. By Lydia E. Becker.

When subjects are debated respecting politics, literature, or science, as they affect the interests of humanity, there is usually no reference to the feminine portion of the race. In questions relating to the supply of food, or to sanitary arrangements, there is no need to refer to women, because every one admits that they are equally liable with men to suffer from hunger and disease, and that they have an equal right to be guarded, as far as possible, from the effects of these evils. Were the same principle of common wants recognized in other questions than those affecting mere physical existence, there would be no occasion to remark on the

absence of provision for women. But women are supposed to have equal needs with men only as regards the conditions of physical life. Their moral and intellectual necessities are imagined to be widely different. The conditions which men find most profitable for the development of their faculties, and the promotion of the highest enjoyment of which a moral and intellectual being is capable, they appear to regard as unsuitable or unnecessary for women. Among these conditions are—1, a liberal education; 2, political representation. When measures are under discussion for securing these advantages to the people at large, it invariably appears that the absence of provision for women proceeds, not on the ground that they are included as a matter of course, but from the absolute exclusion of one-half of humanity, as persons who have no part nor lot in the need for a liberal education, nor for political representation. This systematic and wilful neglect, and the legislative sanction given to it, has produced its natural fruit in the prevalence of the belief that women are endowed with an inferior order of intellect, that they are incapable of being taught to the same extent as men, and that they are naturally unable to appreciate the enjoyment derived from the exercise of the higher intellectual powers. It is a question of serious importance to determine how far this belief is a sound and scientific one. Is there, in truth, such a distinction between the moral and mental constitution of the two sexes, that what is found to be beneficial to the one must be assumed to be prejudicial to the other; that what a man likes and desires, a woman dislikes and deprecates; that the mind of one is progressive, of the other non-progressive; or, admitting that both are capable of development, that then nature is so diverse as to require totally different methods of promoting this development? Because, if there is no such difference in fact, the feminine portion of the race, being debarred from opportunities enjoyed by others of cultivating their mental and moral faculties, must suffer serious deprivation and loss. The magnitude of the privation may be estimated by considering the difference it would make to the men of England if there were neither public schools nor universities to stimulate their intellectual powers, no career or profession open to them wherein they could, by the exercise of these powers, achieve honourable distinction; if in all public movements the position assigned them was that of mere spectators, if their rights and duties as citizens consisted in obedience to the will of others, and if their wishes and opinions were never taken into account in estimating the verdict of the people on questions of national importance. If men would feel the loss of these conditions of mental life to be an incalculable deprivation, it necessarily follows that withholding them from the feminine half of the people must cause equally grievous injury, unless it can be proved that there is a specific and ineradicable distinction between the minds of the two sexes, and that what is good for men is bad for women. Whether such a distinction exists seemed a proper subject of investigation by a scientific society; therefore the following propositions were submitted to the judgment of the Section:—1. That the attribute of sex did not extend to mind; that there is no distinction between the intellects of men and women corresponding to, and dependent on, the special organization of their bodies. 2. That any broad marks of distinction which may at the present time be observed to exist between the minds of men and women collectively are fairly traceable to the influence of the different circumstances under which they pass their lives, and cannot be proved to inhere in each class in virtue of sex. 3. That in spite of the external circumstances which tend to cause divergence in the tone of mind, habits of thought, and opinions of men and women, it is a matter of fact that these do not differ more among persons of opposite sexes than they do among persons of the same; that on comparing individuals, or classes, of men with women, the difference between their mental characteristics will not be greater than may be found between two individuals or classes compared with others of the same sex.

On the Moral and Pecuniary Results of Prison Labour.
By Sir John Bowring, *F.R.S.*

On the Progress of Turkey. *By* Dr. Hyde Clarke.

Agriculture has been favoured by emigration, but very little by machinery. The restoration of cotton culture, which had made great progress, under the encouragement of the Government, is checked by the fall of prices. There is an increase in the quantity and value of imports and exports. The increase in the revenue has been regular, but notwithstanding this there has been an increase of expenditure, and the embarrassments of the Government are notorious. The railway system is producing only limited results, but the telegraph is producing a great effect throughout the empire, has a great effect on the provisional market, and stimulates enterprise to a remarkable degree. There is no ground to believe that any of the elements of the population are becoming extinct. The progress of schooling among all classes, and the development of political rights among the former subject-population, all attest the greater vigour and energy now diffused; but the Government is still far in advance of its subjects, and real progress is dependent on the progress of general practical instruction.

The Past, Present, and Future of the Wage-paid Classes. *By* F. S. Corrance, *M.P.*

After a review of the total, or partial failure to correct or cure, by modern legislation, the social evils of which we most complain, and bringing forward as instances the laws of settlement, poor laws, present and past, prisons, free labour, emigration, and even our sanitary laws and regulations, the author stated his opinion that these unfortunate results had arisen both from an imperfect knowledge of antecedent circumstances, and the ulterior consequences arising out of them. Of the wage-paid class, even the records we possessed were defective and incorrect; and if we wished to form some idea of their social state, no better index could be found than a careful review of the enactments affecting their state. Beyond this our knowledge was confined to some great cataclysms, such as the Black Death in the 14th century, and the Reformation in the reign of Henry VIII.

These enactments embraced laws of settlement and laws of wages and labour, the rate of which it was constantly attempted to fix; instances of this sort occurred under local jurisdiction, even up to the commencement of the present century. Both Lord Kaimes and Andrew Fletcher testify to this.

Under such circumstances and popular conditions we found ourselves brought up to the great developments of the 19th century, when the repeal of most of these laws took place. Some however survived, like the Poor Law and Apprentice Acts, to be denounced by great men like Sir Matthew Hale, Locke, and Mr. Pitt, who foresaw some of the future evils they were calculated to produce. Their full development was nevertheless delayed to a later date.

In the early part of this century a great change took place in the habits of the labouring class; and under the impulse given to production by the introduction of steam power, they emigrated in vast numbers from the south. In Lancashire, which in 1801 had 692,731 inhabitants, there were in 1831 1,333,800; in Yorkshire, East Riding, 1801, 563,953, 1831, 976,400. Cottage industries were given up, and the mass of this population were swept into mills, and constituted a wage-paid class; 35,000 handloom weavers became a pauperized class. To meet this change, what were our legislators about? We had seen their activity at previous periods. This was met by neglect, and a whole generation grew up in ignorance and vice. Yet we wondered at trades unions and strikes.

Up to this time the old Poor Laws were still in force, and though constantly tinkered up, the evils did not fail to increase. A few distinguished men, besides those already named, appeared as reformers of the abuse. After Bentham, came Sidney Smith; and in 1834 some effective legislation took place. The following statistics of certain periods will show to what effect:—

A.D.	Population.	Pauperism.	Expenditure.	Poundage.	Wheat at	Rateable Property.
				£ s. d.	s. d.	£
1834	14,322,000	......	6,317,255			
1844	16,410,000	800,000	4,976,093	1 6 3	......	64,000,000
1854	18,617,000	864,617	5,232,853	1 8 1	61 7	69,000,000
1864	20,663,000	1,014,078	6,423,383	1 4 5	43 2	
1865	20,881,000	951,899	6,264,961	1 4 0	39 8	93,600,000
1866	21,100,000	916,152	6,439,517	......	43 6	
1867	......	1,040,952	6,959,840	......	53 7½	

During part of the same period the emigration has stood thus:—

1861	22,145	England and Wales.
1862	35,487	
1863	61,243	

Of these, the first ten years only show any decrease; and the conclusion is once more reached, that Poor Laws cannot cure a moral evil so deep seated as this.

Nevertheless, thus abandoned, the working classes were not idle on their own behalf. They formed societies of different sorts. Of Friendly Societies, the first was formed in 1793, since which their number has reached 24,800, with 3,000,000 members, and £20,000,000 of assets.

Medical clubs have also been successfully carried out, the chief obstacle being the dependence upon Poor-law relief.

Cooperative Associations are still higher efforts of the same class, and of these 406 at present exist, with 173,243 members, and £1,009,849 of assets.

The Trades' Union is another spontaneous effort of a proletarian class, and associated in antagonism to capital it forms a problem of the gravest character. It must be tested and examined in no unkindly spirit, lest a permanent hostility be the result.

Judging from antecedents, it is but a transitory phase, and its principle of self-sacrifice the only imperishable part.

From such materials it is not easy to predicate the future of the working class. Spontaneous development can only be trusted where education is complete.

For Poor Laws cannot we substitute Friendly and Medical Societies, self-supporting and independent?

For Trades' Unions, a communism of a higher class. Is there no social economy of another order, or gentler code of laws more in accordance with the Christianity we profess? Upon the answer found will depend the stability of our society and the future of the working class.

On the Statistics of Pulmonary Consumption in 623 *Districts of England and Wales. By* EDWARDS CRISP, *M.D.*

The subject is one of great importance as regards the health, happiness, and longevity of the human race; for, notwithstanding the sanitary measures adopted in this and other countries, the author had reason to believe that phthisis was on the increase. It appeared to follow the march of civilization, and its prevalence had a direct connexion with population and the artificial habits and the vitiated atmosphere in which they lived. The author took his returns as to the mortality of England and Wales from phthisis from the Registrar-General's report from 1851 to 1861, dividing the population by the number of deaths, so that the highest numbers indicated the greatest exemption from disease. At Thetford one person in 28 dies from phthisis; and the quantity of stagnant water in and about the town and in the surrounding districts is, in part, sufficient to account for this large amount of mortality. In the following towns in Norfolk, with the districts around, the mortality from this disease is as follows:—Guiltercross 29, Walsing-

ham 31, Milford 32, Erpingham 33, Wayland 36, Tunstead 36, Depwade 36, Norwich 37, Ailsham 38, Flegg 39, Yarmouth 40, Loddon 41, Henstead 41, Blofield 43, Treebridge Lynn 44, King's Lynn 47, Swaffham 47, Docking 47, Downham 48, Forehoe 49, St. Faith's 50. At Chelsea, the number was 28, whilst at Hampstead it was 61, so that while one person in 28 died at Chelsea from phthisis, only one in 61 died from the same disease at Hampstead. With regard to pulmonary consumption, the returns showed that the death-rate corresponded generally with the density of the population; that the general mortality of England and Wales was at the rate of 24·47 per thousand; that in the healthy and more thinly populated districts the rate was only 17·53 per thousand; while in the large towns it was 28·01. In the agricultural part of Surrey it was 18 per 1000, in Westmoreland 18, in Sussex 19, in Lincolnshire 19, and in Dorsetshire 19; while in the metropolitan part of Surrey it was 25, in London 24, Staffordshire 25, Lancashire 27, Yorkshire 23, West Riding 24, and North Riding 19. At Bromley in Kent, at East Hampstead, in Berkshire, and Dulverton, in Somerset, the rate was only 16; at Tenbury, in Worcester, King's Norton, near Birmingham, Hampstead, Pershore, in Worcestershire, Haltwhistle, Bedford, Longtown, and Bootle, the rate was from 14 to 17; at Bellingham, in Northumberland, it was only 14, and at Glendale and Rothbury it was 15. In Wales, the least mortality was at Knighton, where it was 16; in England, the lowest rate was at Bellingham. The total deaths in the ten years were 4,210,715, of which 508,923 were from phthisis, the deaths of females exceeding those of males by 30,313. In the twelve districts of England and Wales, the proportion of cases to population was:—North West 31, Monmouthshire and Wales 32, London 34, Eastern Counties 37, Yorkshire 37, North Midland 39, South Eastern 39, South Midland 40, South Western 41, West Midland 42, Northern Counties 42, so that the West Midland and the Northern Counties were the most exempt, and in the North Western Counties and Wales the disease was the most prevalent. Among sailors, the most fatal stations as regarded phthisis were the western coast of Africa and the Mediterranean. A dry atmosphere, cold or hot, was most frequent in districts where phthisis was comparatively rare. Among some of the causes of phthisis were possibly included, atmosphere, soil, climate, amount of population, nature of occupation, hereditary predisposition, food, and the communicability of the disease. There was no doubt that one frequent exciting cause of phthisis was the exposed state of our railway stations and steamboat piers, which people would hurry to reach in order to save a boat or train, and where, having become heated, they were in cold weather liable to a sudden chill—a matter that should be brought before the House of Commons as one materially affecting the public health.

The object of this paper was especially to show that a moist damp atmosphere, which by many had hitherto been considered the best for those predisposed to tubercular affections of the lungs, was the worst that could be selected. Thus, taking the county of Norfolk, at Thetford, and in the surrounding districts, where stagnant water and fogs were prevalent, the mortality was 1 in 28; whilst at King's Lynn, Downham, and St. Faith's and other places it was considerably less.

The results are obtained by dividing the amount of population by the number of deaths from phthisis *during the ten years named*. Fractions are purposely avoided, because the data are necessarily imperfect, and because such a comparative method for general purposes is better understood.

On Patent Monopoly as affecting the encouragement, improvement, and progress of Science, Arts, and Manufactures. By Henry Dircks, *C.E., F.R.S.E.*

On the New Scheme of Mr. C. Seely, M.P., and Mr. F. P. Fellows for Admiralty Estimates, and "Finance," "Expense," "Manufacturing," and other Accounts, &c., recommended for adoption by the Committee of the House of Commons on Naval Monies and Accounts, and now being introduced. By Frank P. Fellows, *F.S.A., F.S.S.*

The author prefaced his remarks by explaining that for some years he had been

engaged with Mr. Seely in investigating, unofficially, the various Estimates, Finance, and other accounts annually presented to Parliament, and more especially those of the Admiralty.

A description of existing Admiralty accounts and of certain changes made from time to time, will be necessary for this purpose.

In 1864 he commenced his investigations. He found the principal Admiralty documents annually presented to Parliament were,—

1. The "Navy Estimates;" giving the monies required to be voted by the House of Commons for the whole Naval Service for the forthcoming year.

2. Finance Accounts, called "The Savings and Deficiencies on the Grants, &c.," which at the end of the financial year are published to show how much more or less than the amounts voted has been paid for the Naval Service.

3. Accounts called "Navy Ships" Accounts which profess to give the expenditure on each ship building or repairing, and the total so expended during the past financial year.

4. Accounts called "Navy Dockyards and Steam Factories" Accounts, which profess to give the expenditure in each of the 125 Dockyard "Manufactories," the 25 "Factories," and for the various conversions of timber at the saw-pits and saw-mills of each yard. These documents also profess to give the cost and the rate-book price of the several descriptions of articles made or timber converted at each of these manufactories, factories, saw-pits and saw-mills. The rate-book price of articles professes to be the previous year's average cost of articles at the *whole* 7 Home Dockyards.

5. Navy Labour Charts, giving details of labour employed on each ship. [Not now published.]

He found it difficult to ascertain correctly what items of expenditure the Admiralty had or had not included in their given cost of ships built and repaired. He therefore went carefully through the Navy Estimates and Savings and Deficiencies Accounts from 1860–61 to 1863–64 (four years), and picked out, first, merely the amounts voted and paid for wages and ship-building stores bought, thinking the Admiralty must have at least included these. But he found that the amount he thus obtained exceeded the Admiralty given expenditure in ship-building and repairing by about two millions (£1,870,000) [see Hansard, Mr. Seely, March 2, 6, 9, and April 3, 1865, p. 705]. In other words, he ascertained that either the Admiralty stock of ship-building stores had increased £1,870,000, or that £1,870,000 for wages and materials had been omitted from the Admiralty cost of ships built and repaired, or that both causes had operated to bring about this apparent deficit. He then picked out other items from the "Estimates" and "Savings and Deficiencies" that he thought properly chargeable to ships built and repaired, such as wages of foremen, salaries of clerks employed in connexion with shipbuilding, &c., pensions to shipwrights and others, who in consequence of these respective pensions work for about 2*s.* a day less than other shipwrights, and found that these additional items amounted to £1,363,111 [see Hansard, Mr. Seely, March 6, 1865, pp. 1198–1199; also Navy Ships, 'Frederick William,' No. 538, Aug. 13, 1867, p. 27]. Early in February 1865 [see Hansard, Mr. Seely and Mr. Childers, March 2, 1865, pp. 1012–1018], Mr. Seely gave notice that he should bring the subject before the House of Commons, and at the same time he showed these calculations and results to Lord Clarence Paget, the Secretary, and to Mr. Childers, the Civil Lord of the Admiralty; and on the 2nd of March, and again on the 6th, Mr. Seely made speeches on the subject in the House of Commons. To the credit of Mr. Childers, he, as Chairman of a Committee of Admiralty officials then sitting, at once issued instructions to include these omitted items in future Admiralty Accounts [see Navy Dockyard Accounts, No. 465, 4th July 1865, p. 27]. Directly after, Mr. Fellows went to the Admiralty at the request of Lord Clarence Paget, Mr. Childers, and Mr. Seely, where he met Mr. Childers and others, and these calculations were examined and found to be correct; and the Admiralty Navy Ships' Accounts for 1864–65, published in February 1866, No. 44, included for the first time these omitted items, and were consequently far more correct than all preceding accounts; and in the Army Manufacturing Accounts for 1864–65, published 7th March 1866, No. 96, he found for the first time there are additional Balance Sheets, called No. 2, of all

the manufactories made out in a similar manner, and including similar items to his sheet of 1864, shown Admiralty, in 1865 (for copy see Navy Ships, 'Frederick William,' Aug. 1867, No. 538).

The Admiralty in their accounts adopted some of the omitted items thus brought to light, and their forms of balance sheet and accounts were similar to those by which he had been enabled to discover these omitted items. These principles and forms, though the best for his purpose, which was to ascertain the total amount omitted, and the average percentage to be added to ships in consequence, were, however, not the best principles and forms to adopt for an ordinary Admiralty balance sheet; for the proper method in the latter case is to add the indirect and omitted items in *each* Dockyard to *that* Dockyard's Ships, and not to bring them altogether into *one* lump sum for all the yards and then distribute *it* at one *uniform* percentage to every ship built or repaired at any of the 7 Home or 15 Foreign Dockyards.

Later in the session of 1865, at the suggestion of Mr. Seely and Lord Palmerston, on the 16th of June [see Hansard, 16th June, pp. 396–399] he went again to the Admiralty, and early in 1866, on Lord Clarence Paget stating on the 1st of March, 1866, that "The Hon. Member for Lincoln (Mr. Seely) had asked whether his secretary could be permitted to go to the Admiralty in order to correct certain misapprehensions respecting the accounts of the Accountant General of the Navy. The Hon. Gentleman had been of great service to the Admiralty, and he should be extremely glad to go into the matter with him" [see Hansard, March 1, 1866, Paget, p. 1866], he entered into an investigation of the manufacturing accounts (as arranged between Lord Clarence Paget and Mr. Seely) in conjunction with the Accountant General and other Admiralty officials.

Early in 1867 a correspondence occurred between the Controller of the Navy (Admiral Robinson), Mr. Seely, and Mr. Fellows, and an investigation into the true cost of the ships 'Frederick William,' 'Brisk,' and 'Cadmus,' the Admiralty having disputed Mr. Seely's figures. In order to get the true cost of the 'Frederick William,' which was commenced in 1841, and not finished till 1865, Mr. Fellows had to ascertain the percentage to be added to ships generally for the omitted items for each year, from 1841 to 1865. He found that up to 1861 the only items the Admiralty reckoned as having formed part of the cost of ships were the mere labour and materials employed directly in and upon each individual ship; none of the labour or materials used about the ship-yard, and necessary to ship-building, were included. From 1861 to 1864 he found the latter items had been included, and in 1864–65 for the first time were added the items he had discovered as having been formerly omitted.

For this purpose he made balance sheets or tables [see Return, Navy Ships, 'Frederick William,' &c., No. 538, 13th August 1867, pp. 14–18], giving for each year, first, the total cost of ships built and repaired, reckoned for each year, as the Admiralty reckoned, up to 1861. In another column he gave the amounts for each year, consisting of similar items to those included in Admiralty accounts, from 1861 to 1864; in a third column he gave for each year the additional amount of the items, added to Admiralty accounts in 1864–65. So that he had thus for every year, from 1841 to 1865,—

1st. The cost of ships, for each year, reckoned as the Admiralty reckoned, up to 1861. This he called Method No. 1.

2ndly. The cost for each year, reckoned as the Admiralty reckon their accounts, from 1861 to 1864, or Method No. 2.

3rdly. The cost for each year, reckoned as the Admiralty reckoned, in 1864–65, or Method No. 3.

He thus obtained the average percentage to be added to the Admiralty given cost for each year, to get the cost as reckoned by the Admiralty in 1864–65.

The Admiralty, in their accounts for 1865–66, published 22nd July 1867, No. 454, changed for the second time the form of their accounts, and gave the three columns as he had given them in the balance sheets, which were intended merely to enable him to ascertain the approximate percentages to be added for each year to the Admiralty given expenditure in each year of the 'Frederick William,' 'Brisk,' and 'Cadmus.'

Here, again, though these divisions were imperative for his purpose, it does not by any means follow that they were the best for an ordinary account.

He had already completed with Mr. Seely a special system of accounts for the 7 Home and 15 Foreign Dockyards and their 150 different manufactories; and with the view of getting it introduced, Mr. Seely early in 1867 obtained a Committee of the House of Commons to inquire into Admiralty monies and accounts, and finding on inquiry from the Accountant General that an Official Committee (which had been appointed directly Mr. Seely gave notice that he should move for a Committee of the House) had no forms or schemes to propose, and could come to no agreement or conclusion amongst themselves, Mr. Fellows gave and explained the new scheme of accounts to Mr. Beeby (the Accountant General), Mr. Walker, and Mr. Brady, of the Admiralty, before Easter. Mr. Seely's Committee finally recommended the adoption of this scheme in its entirety, with certain minor modifications that had been jointly agreed upon between the Admiralty officials and Mr. Fellows at their interviews before Easter [see Report, Admiralty Monies and Accounts, 27th July 1868, No. 469, p. iv, par. 10; p. v, par. 13; pp. xv, xvi, pp. 305 to 322; p. 362. Q. 5761; and on p. 370. Q. 5899; and Appendix, pp. 598 to 603]. This scheme is now being introduced into the Admiralty. It reverses the previous system of Admiralty accounts. The practice had been to treat the whole 22 Dockyards, with their 150 manufactories, as one great establishment, so that articles made for ship-building or timber or materials converted, say, at Devonport, costing on an average 20 per cent. *below* the average of the other yards, were yet charged to Devonport's ships at the average cost of all yards; and articles &c. costing, say, at Portsmouth, 20 per cent. *more*, were similarly charged; so that, though there might be a difference of 40 per cent. between the cost of articles &c. at Devonport and Portsmouth, yet these articles &c. were charged at the same prices to ships built at both places.

Respecting the 150 manufactories and the saw-mills and saw-pits in which are made or converted the articles or materials used in the construction or repair of ships at each yard, he found that the so-called cost of timber converted or articles made excluded many items forming part of their real cost; as, for instance, the timber as charged to ships did not include the cost of freight, measuring, receiving into and issuing from store, the expenses or labour in taking it to or from the saw-mills or saw-pits, or to the ships where used (these items in 1865–66 being about £200,000); nor the wages of converters of timber, measurers, foremen, and clerks connected with the timber conversions, though he found that in one yard he examined the omitted salaries amounted to a larger annual sum than *all* the wages paid for the sawing and conversion of the timber itself, this latter being the only item for labour of any kind charged to the timber when converted; in fact it only included part of the cost of labour, and really only part of the cost of material, since freight &c. really adds to such cost. The same remarks will also apply to all the manufactories and factories; the only items reckoned and included in the cost of their articles being part, and part only, of the cost of labour and material, all charges for foremens' wages and supervision and indirect expenditure being omitted altogether from such cost.

The new Scheme reversed all this, and was based on the principle that each manufactory should be treated as if it were the only manufactory carried on by the Admiralty; that all items of expenditure connected with it, direct or indirect, should be charged to its products, and the thus properly enhanced price should be the price at which the articles should be issued and charged to ships; that all indirect charges in each dockyard that could not be appropriated and charged to the products of any manufactory in any yard should finally be distributed on the ships built and repaired in the yard where such expenses were incurred. Lastly, it established a connexion between the Navy Estimates [which give the money to be voted] with all the succeeding accounts, by which the money as voted by the House could be readily traced and checked in all of them. This introduced a new principle into both what may be called the parliamentary accounts and the departmental accounts or detailed accounts of expenditure, such as cost of ships, articles made at the manufactories, &c. By it a unity was created which did not exist before between the parliamentary and the departmental accounts. This Mr. Fellows considered one of

the best and most novel parts of the scheme. The particular result, so far as the Admiralty is concerned, is that in future when the House votes money it will practically ensure its proper appropriation, and the given cost of ships built and repaired must balance *in each yard* certain sums of money, as voted or arranged and tabulated in the estimates when voted by the House; therefore in future it will be impossible for the Admiralty to add or omit items at pleasure from their given cost of ships. The importance of this will be at once seen when we consider that a ship costing £100,000, reckoned as the Admiralty reckoned up to 1861, would be given as costing £120,000, reckoned as the Admiralty reckoned from 1861 to 1864, and from £140,000 to £160,000 reckoned as in 1864–65 and 1865–66; or, in other words, of the £11,000,000 voted for the whole naval service, it was in the power of the Admiralty to make out their accounts of the cost of ships so that it might appear that they had spent £2,000,000 only for ship-building, when £3,000,000 had been actually expended, or *vice versâ*.

Finally, the great practical result that is to be expected from this reversing of the previous system is, that a competition in efficiency and cost will be established between manufactory and manufactory, between yard and yard, which was wanting before, and that in future Devonport's or any other yard's economy shall not be hidden and taxed to hide and to pay for Portsmouth's or any other yard's extravagance.

On Educational Endowments. By J. G. Fitch, *one of the Assistant Commissioners of the late Schools-Inquiry Commission.*

The Commission had been presided over by Lord Taunton, and had presented an elaborate report within the last year. It had not been instructed to inquire into those endowments which were designed to promote elementary education, nor into those of the nine great foundation schools, including Eton, Harrow, and Winchester. Its work had extended over the whole of the vast field of investigation lying between these two extremes; and within this area it had found no less than 820 endowed foundations which had been intended to give, or which were now actually giving secondary or higher education. The gross annual revenue of the charities to which these schools belong is £336,201. But of this sum a part is appropriated to the maintenance of almshouses or other eleemosynary objects, and that income, after all deductions are made for management, amounts to £195,184 for the maintenance of the schools, besides £14,264 in the form of exhibitions, generally intended for the use of such pupils as proceed to the universities. These sums, however, represent very inadequately the resources of the foundation schools; for besides these there is in nearly every case a freehold school-room, besides grounds and a dwelling-house or houses for the master and for the reception of boarders. All this is, of course, additional to any fees which may be charged to parents, and may be considered as a provision either for enabling scholars to obtain superior education without payment, or at least for cheapening education for those who could only afford to pay a portion of its market price. The amount of endowment varies considerably. The richest foundation in the kingdom is Christ's Hospital, with a net income of £42,000, while a few are endowed with nothing more than a small tenement which serves as a school-house, and a rent-charge of £5 or £10 per annum. There are nine foundations with incomes exceeding £2000, thirteen others with upwards of £1000, fifty-five with less than £1000 and more than £500, 222 with less than £500 but more than £100, while the remainder are endowed with less than £100 per annum each. Similar inequalities appear in the local distribution of the schools, although the modern facilities of communication render this a minor evil, one which scarcely calls for a remedy, except so far as *day* schools are concerned. Yet the Commissioners report that in the London district the net sum arising from grammar-school endowments is £56,000; in Yorkshire, upwards of £18,000; in Lancashire, £9000; Lincolnshire, £7000; while Cornwall, which stands lowest on the list of counties, has no more than £400, and buildings of very little value. But the most serious revelations of the Commissioners relate to the educational condition of the schools. On this point the evidence is very copious, occupying nearly twenty volumes, and it is almost

impossible to summarize it. But the total number of boys professing to belong to these 820 schools is 9279 warders and 27,595 day scholars, a number wholly inadequate when the capacity of the school-rooms and the resources of the trustees are considered; and of this number very few are receiving the classical education contemplated by the founders, while the general instruction in other subjects is, as a rule, of very inferior quality. Indeed the very existence of the statutes prescribing the ancient learning often serves as an excuse for withholding any modern addition to it. It had been his own duty as Assistant Commissioner to visit about 120 schools, and to report thereon to the Commission. Of these there were perhaps twenty which deserved the name of good schools, including five or six which stood in the foremost rank for efficiency; but of the rest scarcely any would pass muster as respectable National Schools, while the large majority were, in material equipment, in method, in the quality of the instruction, and in the brightness and mental activity of the scholars, very much below even that humble standard. Similar evidence abounded in the reports of the Assistant Commissioners, particularly in those of Mr. Fearon and of Mr. Bryce. The paper proceeded to discuss the constitution of bodies of trustees, the freehold tenure of the masterships, and other hindrances to the proper development of the schools. At present three authorities exist for rectifying abuses and creating new schemes—Parliament, the Court of Chancery, and the Charity Commission; but no one of them ever initiates proceedings, or deals with a school or group of schools on any general plan. They provide no security for the continued efficiency of the schools, or for their development according to the future needs of the people. Above all, Parliamentary and Chancery schemes for single institutions are all alike hampered by an attempt to keep as close as possible to the intentions of the founders—an attempt which often perpetuates capricious and mischievous regulations, and puts a bar to future improvement. The statesmanship of the future would probably reverse the whole law of inheritance, and ask boldly by what right the pious founders of these institutions were to go on for generations legislating on a subject on which private, irresponsible, and local regulations were likely to be especially mischievous, and on which the supreme intelligence of the nation, as represented in Parliament, ought first to be heard. By the law of France, no man is permitted to bequeath money for any public purpose to a private corporation of trustees nominated by himself; every such bequest, if made at all, must be confided to the administration of a *personne civile,* or some Corporation, municipal or otherwise, known to the law, and responsible to the civil authority. Instances were given showing the need of some energetic restraint in this country on the power a testator now possesses of enacting laws with a view rather to gratify his own vanity or selfishness, or to promote some false theory of education, than to promote the public interest. Meanwhile the Royal Commissioners had not recommended any change in the law of inheritance; but they had put forth a plan for organizing and utilizing the existing endowment, which deserved the earnest attention of the public. They proposed to establish in each of the eight divisions of the Registrar-General a local Board of Commissioners, with power to fix the grade of each endowed school, to convert useless or effete endowments into exhibitions, to rearrange, where necessary, the local distribution of the schools, to institute periodical inspection, and to report publicly on each of them. These local Boards are to work in harmony with a central authority, to be formed by enlarging and strengthening the present Charity Commission, and by giving to it a more distinctly educational character. Another of the Commissioners' recommendations was, that there should be a Council composed of representatives of the Universities, which should be empowered to examine and to certify teachers of all grades, and to give unity and system to other general examinations, whether obligatory on the endowed schools, or voluntary in relation to private schools. By this and other means, which were described in detail, it would be possible to introduce order and organization into the chaos of our secondary instruction, and possibly at some future time to absorb the present machinery of the Privy Council Office, and thus to give unity to the education of the whole country. Measures like this would, when the time came for discussing them in Parliament, encounter much opposition, partly from self-interest, and partly from a traditional tenderness towards the wishes of testators, which had

become a sort of social superstition in England; but when that time came, it was hoped that the members of the British Association would be prepared to give their support to the recommendations of the Commission.

Inventors and Inventions. By G. BELL GALLOWAY.

The Condition of the Agricultural Labourer, specially in the West of England. By the Rev. EDWARD GIRDLESTONE, *M.A., Canon of Bristol.*

The progress of manufacture so far from lessening has rather increased the value of land. Fortunes made in manufacture are generally invested in land. Skill acquired in manufacture is applied to land. Great Britain retains and is likely always to retain its character as an agricultural country. Landowners occupy the highest positions and enjoy the greatest social previleges. Public opinion, the reform of universities and public schools, the facility for foreign travel, and the admixture of the manufacturing classes with the old landed proprietors have much raised the character and improved the tone of these last. Still, especially in the West of England, there are many persons remaining who resist all progress. The race of farmers is also much improved, but not so much in the West of England as elsewhere. The land is also much improved; a larger acreage is brought into cultivation, and each acre is made to yield more. In this respect, also, in the West of England there is less improvement than elsewhere. Nowhere has the improvement of the agricultural labourer kept pace with that of the landowner, the farmer, and the land itself. In the West of England the condition of the labourer is very little improved, and in some respects is worse than it used to be; wages are low, fuel and provisions dearer. Education has become a necessary of life for a family. The poor-rate is so administered as to quench every feeling of independence. In the West of England an agricultural labourer had, till lately, only 7*s.* or 8*s.* a week, and now only 8*s.* or 9*s.* Unless he is a horsekeeper or a shepherd, he has to pay out of this from 1*s.* to 1*s.* 6*d.*, or more, a week, for house-rent, and to provide food, clothing, medical attendance, fuel, and every other necessary for himself, wife, and family. Potatoe ground he pays a high rent for; and fuel he seldom gets except at a cost of as many hours of hard work in getting it as are its full value. He has three pints or two quarts of cider a day, and has a portion of his wages often paid in grist, which when corn is dear is an advantage, but otherwise a loss to him. He is often not allowed to keep a pig or poultry for fear of stealing food for them from his master. He works, nominally, ten or ten and a half hours a day, with an hour and a half deducted for meals. He is almost always, however, in reality kept a much longer time than this, and is seldom paid anything for overtime, except by bread and cheese in harvest time. Women get 7*d.* or 8*d.* a day for outdoor work, with a quart of cider, and boys smaller sums in proportion. The men breakfast before they leave home on teakettle broth, which consists of an infusion of bread and water with a little milk, when it can be got. For luncheon or dinner, which they take with them, they have coarse bread and a little hard, dry, skim-milk cheese at 3*d.* per lb. For supper, on their return home, they have potatoes or cabbage, with a very small slice of bacon sometimes to give a flavour. Butchers' meat they seldom get except it is given to them. They are unable to lay by anything; and few comparatively belong to benefit societies. They are long-lived, but even in their prime feeble, and at the age of fifty often crippled with rheumatism, the result of poor living, sour cider, a damp climate, hard work, and anxiety combined. There remains nothing for them then but parish pay and the Union. There are many exceptions to this general rule, often even in contiguous parishes, owing to the presence of an intelligent resident land-owner, or the immediate neighbourhood of a large town, mines, or manufactures. In other parts of England the rates of wages differ much. The wages of the agricultural labourer are always higher in the neighbourhood of towns, mines, and manufactures. More than 100 labourers have been sent from the parish of Halberton and other parts of North Devon into Bedfordshire, Cheshire, Derbyshire, Durham, Glamorganshire, Hampshire, Hert-

fordshire, Kent, Lancashire, Shropshire, Surrey, Yorkshire, more than half being married men with families, at wages varying from 12*s.* a week, the lowest, with house and garden rent free, to 20*s.* a week, with house and garden rent free. In all cases the house and garden were rent free, and in some cases there has been fuel and potatoe ground, one or more, given in addition. The single men who have been sent away are getting from 6*s.* to 8*s.* a week, with board, lodging, and washing.

From the above statement it is clear that the condition of the agricultural labourer is in different parts of the country very different. But notwithstanding statistics, which in this, as in the case of education, are very deceptive, and general statements made by persons of no experience, the fact that in agricultural districts the poor-rate is very high, that there are more marks than signatures in the marriage registers, that recruits from the same district are seldom able to read or write, that our prisons are filled from the same districts, and the general conviction that agricultural labourers are wholly unfit to be trusted with the franchise, are real and reliable evidences of the low condition of this class of men. That which is really required for the agricultural labourer is, in one word, independence; at present he is the most dependent of any class of labourers. To effect this:—*First*, good wages in proportion to quantity and quality of work, but always, in the case of an able-bodied and industrious man, enough to keep him and his family, with a margin for insurance against old age and sickness, are required. *Secondly*, also well-drained and ventilated houses, with at least three bed-rooms, and all other appliances for decency, with a provision also against taking in lodgers, such houses to be in the control of the landowner rather than of the farmer. *Thirdly*. Greater facilities for education. Even a penny a week for each child in a large family is a heavy tax on a very small income. The temptations held out by the farmers of a few pence for boys to keep birds and do other child's work is too great for the poor labourer to resist. No child should be allowed to work till he can read and write well, and has a fair knowledge of the first rules of arithmetic. *Fourthly*. All mops and hiring fairs should be abolished, and a good system of registration be generally adopted and made known through the instrumentality of the penny papers throughout the country. *Fifthly*. Agricultural Labourers' Unions, of a strictly protective character, and well guarded against intimidation to either employers or fellow workmen, might be formed with advantage. The whole system of unions is not to be condemned because of the outrages committed by a few. All professions, all trades, even landowners and farmers, in their Chambers of Agriculture, have their unions. Why are agricultural labourers alone to be left to struggle hopelessly, because singly, while all others are combined? *Sixthly*. There should be legislation in favour of the agricultural labourers, specially as regards education, and the administration of the Poor Law by a central board of disinterested officers instead of a local board of landowners and farmers. Legislation, so far, has done less for this than for any other class. Landowners and farmers have a special pecuniary interest in the improvement of the agricultural labourer. The clergy have a spiritual interest. All bread-winners ought to help him to raise himself to the same independence to which all except he has attained. All that can be done by an individual is to cooperate with any persons who are willing to take this good work in hand; or, failing the attempt thus to carry the work out on a large scale, one must content himself with carrying it on in a small way in his immediate neighbourhood.

On the Drainage of the Fens of Cambridgeshire, Huntingdonshire, Norfolk, and Suffolk. By W. D. Harding, *C.E.* (*King's Lynn*).

That part of the great level of the fens called the Bedford level, extending into the counties of Cambridge, Norfolk, Suffolk, and Huntingdon, comprising about 300,000 acres, was first attempted to be drained in the early part of the seventeenth century, and has been gradually improved from that period up to the present time. The early adventurers, aided by the Duke of Bedford, made upwards of 100 miles of new rivers, to convey the drainage waters to their outfall.

In the early part of the eighteenth century the fen-men, in consequence of the

bad state of the new rivers, were compelled to erect a great number of windmills for their drainage, and continued to use them till the early part of the nineteenth century, when very powerful steam-engines driving large scoop wheels were substituted for the windmills; and at the present time all the low lands are drained artificially by these engines, which amount to about 1000 horse-power.

In the year 1821 a very important work was carried out for the improvement of the outfall by making a new cut above the town of Lynn, called the Eau Brink Cut, which is 3 miles long, and which lowered the water in the upper river in flood time 10 feet; this work cost about £100,000.

The next work of importance was the New Middle Drain, which was completed in the year 1848, which was 11 miles long, and which commenced at Upwell and extended to Saint Germans, and was dicharged at the upper end of the Eau Brink Cut. This drain, with the outfall sluice, and making the internal rivers of the middle level correspond with the new drain, cost upwards of £400,000, which was apportioned upon the 110,000 acres of the middle level.

In the year 1862, the outfall sluice of this drain gave way, and allowed the tide to flow up, and ruptured one of the banks, and inundated about 6,000 acres of land: since that period the middle level has been drained by sixteen syphons, 3 feet 6 inches diameter and 20 feet high, which are worked by a ten horse-power engine, exhausting the air from the inside by means of an air-pump, and up to the present time they have drained this large tract of land.

In the year 1852, a further improvement to the outfall was made by the making of the Norfolk-estuary cut, 3 miles long, below Lynn, which cost about £250,000, and which again lowered the water at low water from 3 to 4 feet.

Notwithstanding these great improvemonts, and these large sums of money which have been laid out, the greater part of the fen-country is drained by artificial means, and will continue so till some further great works are carried out for the improvement of the same.

Sanitary state of Indians in the Settlement of Kanyeageh, Canada, 1868. *By* James Heywood, *M.A., F.R.S.*

A considerable number of Indians are scattered as farmers and farm-labourers in the Indian reserve of Tuscarora, near Brantford, in Canada. The New-England Company have several missions for the Indians of that reserve, and a new church has been recently erected at Kanyeageh, in the north-west portion of the district, which on Sunday contains about 300 Indians, the half of whom are males and the other half females. The Rev. R. J. Roberts, Church of England missionary at this station, has collected the following details respecting the health of the Indians in his neighbourhood who are connected with the Church of England.

Ague is the most common disorder in the Indian reserve, and this malady is attributable to the numerous swamps in the forest. The Indians of that locality may be regarded as perhaps somewhat more liable to consumption than the whites.

During the half-year from the 1st January to the 30th June, 1868, there were seventeen interments of Indians, either in Kanyeageh Churchyard or in some other burial-grounds within four miles of that station; and the diseases in these cases, where known, are thus enumerated:—

Males.

No.	Aged.	Cause of death.
1	3 years	Not known.
2	11 „	Inflammation.
3	17 „	Diphtheria.
4	18 „	Inflammation.
5	25 „	Consumption.
6	26 „	Consumption.
7	27 „	Consumption.
8	72 „	Softening of the brain.

FEMALES.

9	4 months	Ulcers.
10	1 year	Not known.
11	1 „	Scrofula.
12	7 years	Cold.
13	33 „	Consumption.
14	41 „	Abscess.
15	52 „	Consumption.
16	56 „	Consumption.
17	83 „	Gradual decay.

Within a recent period the New-England Company have commenced the drainage of swamps in the immediate vicinity of Kanyeageh, but more comfortable and better ventilated dwellings are required for the Indians. The food taken by the Indians is often insufficient and unwholesome, and their clothing does not serve to keep out the cold of a Canadian winter.

A wooden building is in course of erection near the church for a school-house. The hours of school are to be from 9 A.M. to 4 P.M., with an hour of intermission from 12 to 1 o'clock. The Indians of this station have given up wandering, and are now settled down as farmers, having no inducement for leaving the reserve. Their employments consist in farming, and the manufacture of axe-handles, sledges, stable-brooms, and whip-stocks. The women make baskets, straw hats, and bead-work.

The consumption of spirits by the Indians of the reserve is much less than it was formerly. One of the Government medical officers of the Indian reserve has informed the Rev. R. J. Roberts that "the consumption of spirits by white people is much greater than by the Indians of this settlement." Among the Indians there are several temperance societies.

A Brief Statement of the Recent Progress and Present Aspect of Statistical Inquiry in relation to Shipping Casualties. By HENRY JEULA, *F.R.G.S., F.S.S., Hon. Sec. to Statistical Committee at Lloyds'.*

On the Arterial Drainage of Norfolk. By Sir WILLOUGHBY JONES, *Bart.*

The subject of the arterial drainage as distinguished from the fen-drainage of Norfolk may be defined to be a description of the watercourses that find their own way into the sea, instead of having their contents pumped into it by steam or other power.

The rainfall of Norfolk has been variously stated at from 24 to 26 inches; it is much to be desired that the rainfall not only of Norfolk but of England generally was more accurately determined, and that a more regular, uniform, and accurate system of registering the rainfall was generally adopted. By making use of the union houses and prisons as rain-gauge stations, the gauge being uniform in make and in height above the soil, and the results uniformly registered by the governor or some member of the resident staff, this might easily be accomplished.

The evils of water-mills in a flat country are strongly evidenced by the condition of the Norfolk valleys. Everywhere the streams have been treated as means of obtaining power to grind corn and not as drains or watercourses. The result is that every foot of fall is utilized, and the streams are still water between mill and mill. Often the bed of the river is raised some feet above the land on either side, the result being that much valuable land is destroyed for want of drainage, and the villages and towns in the valleys are very unhealthy from fevers and other forms of malaria. The *Anacharis alsinastrum* is another cause of obstruction, the rivers in many places being almost choked by it; and it being nobody's duty to keep them clear, this evil keeps increasing.

The river system of Norfolk itself is very peculiar. The country is in fact an island, no stream flowing into it from any other county, and no stream flowing out of it. The sea, the fens, the Little Ouse, and the Waveney entirely surround it, the

two last rivers rising one on each side of the high road at Lopham. There is a system of small streams that flow into the sea on the north, a similar system flows into the fens on the west, and all the rest of the drainage of Norfolk, including about two-thirds of the county, flows into the sea under Yarmouth bridge.

The navigation for twenty miles from Yarmouth to Norwich is fairly kept up; but generally the drainage system is in a deplorable state, as might be expected in a very flat country where human ingenuity seems to have been employed in obstructing instead of helping off the water.

The Waveney-valley improvement act offers some gleam of hope for the future; but the powers of the act are insufficient, greater care having been taken to conciliate the owners of water-rights than to provide for the escape of water in a river the fall of which is not more than a foot to a mile, or thereabouts.

On the Progress of Learned Societies, illustrative of the Advancement of Science in the United Kingdom during the last Thirty Years. By Prof. LEONE LEVI, *F.S.A., F.S.S.*

The author drew attention to the number and description of our learned societies, and to their progress, as a sure indication of the advance of science. A scientific census could not be taken by the number of their members, many men of the highest scientific attainments not belonging to them, many who have several initial letters attached to their names being rather the patrons than the cultivators of science, and many belonging to several societies; yet the author estimated that the total number of men directly contributing, by their learning or their wealth, to the promotion of science constitutes about 15 in every 10,000 of the population. Taking, moreover, the total income of such societies as a basis, it appears that the resources of science amounted to £4 to every £10,000 of the national income charged to income tax, such facts contrasting most favourably with the time when Mr. Babbage wrote his 'Reflections on the Decline of Science in England,' and when the British Association was first formed, in the year 1830. Having dwelt at length on the circumstances attending almost every scientific society in the United Kingdom, from the returns made by the societies themselves in answer to a circular he issued, the Professor concluded his observations with the following statement:—1. That during the last thirty years there has been a large increase in the number and membership of learned societies in the United Kingdom, a fact indicative of a decided advancement of science. 2. That, classified into distinct groups, the membership of learned societies has advanced in the following ratio:—

Number, Membership, and Income of Learned Societies.

Royal Societies.

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
								£
1662	Royal Society	1835	793	1867	651	......	18	3983
1783	Royal Society of Edinburgh	1831	358	......	350	......	2	......
1750	Royal Irish Academy	1838	345	......	358	3	......	1210
3		3	1496	3	1359		9	5193

Mathematical and Physical Science.

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
1834	Statistical Society	1838	402	1867	371	......	7	779
1865	London Mathematical Society..........................	......	......	......	111	......	......	100
1820	Royal Astronomical Society.	1836	324	......	528	62	......	1179
1841	Chemical Society	......	......	......	192	......	......	1086

Mathematical and Physical Science (*continued*).

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
								£
1850	British Meteorological Society	......	......	......	306	......	......	336
1823	Geological Society of London	1834	641	......	1100	71	......	1900
1859	Geologists' Association	......	......	......	230			
......	Meteorological Society of Scotland	......	......	......	520			
......	Manchester Statistical Society	......	......	......	162			
9		3	1367	9	3520	186		5380

Biology and Natural History.

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
1840	Ethnological Society	1848	......	1867	219	......	......	300
1863	Anthropological Society ...	......	......	......	1031	......	......	1327
1788	Linnean Society	1831	539	......	482	......	9	1380
1833	Entomological Society	1834	115	......	208	80	......	380
1804	Royal Horticultural Society	......	1700	......	3595	111	......	11000
1826	Royal Zoological Society ...	1838	3008	1868	2923	......	3	25042
1836	Royal Botanic Society	1840	300	......	2422	707	......	6946
1839	Royal Agricultural Society..	1840	2569	......	5525	115	......	5069
1836	Edinburgh Botanical Society	......	......	......	368			
1851	Glasgow Natural Society ...	......	......	......	120			
	Yorkshire Agricultural Society	......	......	......	500	......	......	3000
	Ulster Chemical Agricultural Society	......	......	......	218			
1853	Wiltshire Natural History Society	......	......	......	313	......	......	170
13		7	8231	13	17924	117		54614

Geography and Archæology.

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
1830	Royal Geographical	1831	535	1867	2102	292	......	5981
1572	Society of Antiquaries	1831	781	......	651	......	16	1823
1864	British Archæological Association	......	......	......	480	......	......	476
1843	Royal Archæological Institution of Great Britain and Ireland	......	......	......	697	......	......	880
1845	Norfolk and Norwich Archæological Society	......	......	......	175	......	......	127
1840	Cambridge Antiquarian Society	......	......	......	65	......	......	......
1852	Worcester Diocesan Architectural Society	......	......	......	120	......	......	......
	Somersetshire Archæological and Natural History Society	......	......	......	392	......	......	......
1834	Tweedsdale Physical and Antiquarian Society	......	......	......	100	......	......	......
	Lincoln Diocesan Architectural Society	......	......	......	260	......	......	114

Geography and Archæology (*continued*).

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
1834	Suffolk Institute of Archæology and Natural History	......	......	......	168	......	......	£ 85
	Buckingham, Records of ...	......	......	......	250	......	......	......
1847	Liverpool Architectural and Archæology Society	......	......	......	169	......	......	115
	Kent	......	......	......	900	......	......	......
	Cork Cavierialn and Archæological Society	......	......	......	40	......	......	......
	Lancashire Historic Society.	......	......	......	409	......	......	......
1856	Glasgow Archæological Society........................	......	......	......	70	......	......	......
	Scotland Society of Antiquaries........................	1852	238	......	304	......	......	......
18		3	1554	18	7352	373	......	9601

Applied Sciences.

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
1753	Society for the Encouragement of Arts, Manufactures, and Commerce......	1831	1148	1867	3278	185	......	7472
1818	Institute of Civil Engineers.	1834	200	......	1698	749	......	6762
1857	Institute of Engineers, Scotland..........................	......	......	......	396	......	......	550
1856	Society of Engineers	......	......	......	483	......	......	1000
	Institute of Engineers, Ireland..........................	......	......	......	68	......	......	100
	Institute of Mechanical Engineers........................	......	......	1865	572	......	......	1926
	Clinical Society	......	......	......	200			
1841	Pharmaceutical Society	......	......	......	2500	......	......	4281
	Obstetrical Society............	......	......	......	600			
1831	Royal United Service Institution	1831	1437	......	3283	128	......	3467
1834	Royal Institute of British Architects	1836	138	......	623	351	......	1523
	Pathological Society	......	......	......	400			
1848	Institute of Actuaries	......	......	......	228	......	......	336
	Royal Medical and Chirurgical Society of London...	1833	633	......	641	......	......	1400
14		5	3556	14	14970	453	......	28817

Miscellaneous Sciences.

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
1839	Royal Microscopical Society..........................	......	......	......	360	......	......	343
1842	Philological Society	......	......	......	202	......	......	180
1823	Royal Asiatic Society	1834	405	......	320	......	20	827
1836	Numismatic Society	1839	169	......	164	......	3	164
4		2	574	4	1046	....	82	1514

Scientific and Philosophical Institutions.

Date of foundation.		Date.	No. of members.	Date.	No. of members.	Per cent. of Increase.	Per cent. of Decrease.	Income per last Report.
								£
1799	Royal Institution of Great Britain	1830	736	1867	889	20	......	5247
1805	London Institution	1830	900	......	904	......	......	2989
1781	Manchester Literary and Philosophical Society......	......	......	......	164			
1868	Edinburgh Philosophical Institution	......	......	......	1820	......	......	2241
......	Leamington Philosophical Society........................	......	......	......	144	......	......	251
......	Leicester Literary and Philosophical Society	......	......	......	160			
6		2	1636	6	4081	149	......	10728

Printing Clubs.

1858	Manx Society	......	......	......	150	......	......	155
1844	Ray Society......................	......	......	......	586	......	......	745
1848	Chetham Society	......	......	......	350			
1853	Ossianic Society	......	......	......	560	......	......	100
4		......	......	4	1646	......	......	1000

National Associations.

1830	British Association for the Advancement of Science ...	1831	900	......	3629	303	......	2964
1856	National Association for the Promotion of Social Science	......	......	......	1600	......	......	1640
2		1	900	2	5229	......	......	4604

Recapitulation.

Number of Society 30 years ago.	Number of Society now.	Sciences.	Number of Members 30 years ago.	Number of Members now.	Percentage of increase.	Percentage of decrease.	Present income.
							£
3	3	Royal Society	1496	1359	......	9	5193
3	9	Mathematical and Physical.	1367	3520	179	......	5380
7	13	Biology and Natural History	8231	12924	48	......	54514
3	18	Geography and Archæology.	1554	7352	373	......	8601
5	14	Applied Sciences	3556	14970	453	......	28817
2	4	Miscellaneous Sciences	574	1046	82	......	1514
2	6	Scientific and Philosophical Institutions....	1636	4081	149	......	10728
......	4	Printing Clubs	......	1646	......	......	1000
1	2	National Associations	900	5229	486	......	4604
26	73		19314	57127	......	......	120351

3. That there are at present upwards of one hundred and twenty learned societies in the United Kingdom, having in the aggregate upwards of 60,000 members, and deduction made for members belonging to more than one society, upwards of 45,000 persons engaged or directly concerned in the promotion of science, with a collective income of upwards of £130,000. 4. That it seems desirable to render the published *Transactions* of such societies as complete as possible by the addition of a summary of the discussions which arise out of the reading of scientific communications and papers. 5. That considerable advantage and economy would result by locating several societies in the same building, the members having mutuality of privileges, especially as regards the use of large rooms for meetings and the common use of the libraries. 6. That the councils of all the learned societies should annually meet together to consider the state of science, and the relation of each to education and legislation. 7. That the relation of the State to the learned societies, money grants or house accomodation being made to some while others are entirely ignored, does not appear to proceed on any well-established principle 8. That the institution of a medal annually granted to distinguished merit, appears, from the experience of some societies, well calculated to afford stimulus to the pursuit of science. 9. And that a united meeting of the members of all learned societies should be held for the presentation of such medals, and for the greater encouragement to science, in the "Royal Albert Hall of Arts and Science," now in the course of construction, as a memorial to that munificent patron of science, who with so much wisdom and dignity presided over one of the meetings of the British Association. [See Appendix, p. .]

On the Present State of the Question of International Coinage.
By Prof. LEONE LEVI, *F.S.A.*, *F.S.S.*

Having shown the practical character of the question at issue, and the importance attached to it by the juries of international exhibitions, the statistical congresses, the chambers of commerce, the Society of Arts, and other public bodies, he examined the respective advantages of either adopting a new unit altogether for all nations, or one of the existing units by all of them, or a correlation of all the different units. The first plan, of adopting five or ten grains of gold as a new unit, would be impracticable, because it would require a general recoinage by all nations. The second plan, that of choosing one from the existing units, was better; and the choice would depend on the number of persons among whom the same unit is already in circulation, the amount of trade which is regulated by such unit, the amount of coinage of the same already issued, and the relative convenience of the different systems. As regards the population, the pound circulates in England with 30,000,000 of people; the franc in France, Italy, Belgium, Switzerland, which have collectively 70,000,000; the dollar in the United States, which have 31,000,000; the florin in Austria, which has 34,00,000; the thaler in Germany and Prussia, which have 54,000,000; and the rouble in European Russia, having 59,000,000 of people. The franc, therefore, prevails among the largest number of persons. As regards trade, whilst the imports and exports of England in 1865 amount to £490,000,000, those of France, Italy, Belgium, and Switzerland in the same year amounted to £480,000,000, and those of the United States to £105,000,000. England here has the preeminence, though not so decided as one might imagine. And as regards the amount of coinage issued, whilst up to 1850 the issue of gold coin in England far exceeded that of France and the United States, it has not been so since that time. From 1793 to 1866 France issued £262,500,000 of gold coins; the United Kingdom, from 1816 to 1866, £187,000,000; the United States, from 1792 to 1849, £109,000,000. Since 1850, France, £197,000,000; the United Kingdom, £91,000,000; the United States, £152,006,000. As regards the relative convenience of the different systems, it was a fact that, whilst this country has been for years labouring to establish a decimal coinage, France and the United States long possessed it; whilst, moreover, for international purposes, the pound was too large a unit. In three, therefore, out of the four elements, France has the advantage, and that induced the Congress to take the French coin as a basis. But the Congress did not recommend the franc as a unit for all nations, nor did it

recommend the pound. As a step in advance, it recommended a mode of harmonizing the different systems in existence, according to which we should alter the pound to 25 francs exactly, instead of 25 francs, 20 cents., as it is now intrinsically worth. Can this be done? Should this compromise be accepted, the evil was, that it would cause a great change in all the monetary systems. It would require us to lower, though in an infinitesimal manner, the gold standard, and yet leave all the existing units in existence. The accounts would still be kept in different ways, the divisional coins would in nowise agree, and we should not get a good decimal coinage. The author thought that the 10-franc piece in gold, of the value of 100 new pence (slightly diminished in their present relative value), with the unit of 100 francs, or £4, for larger financial operations, was the best unit offered for all nations. Such a unit, divided into ten silver pieces of 10*d.* each, would give also an excellent decimal coinage, producing immense facilities in education and great ease in calculations. And in that way we should have one unit identically alike everywhere, instead of the 100 units now in existence, and the identity would be obtained, not only in the gold unit, but in its subordinate coins of silver and copper. Allowing that the International Monetary Congress had immensely advanced the question, he trusted that the Report of the Royal Commissioners would recommend the holding of another conference for the purpose of considering the possibility of agreeing in one common system of coinage, instead of the proposod adaptation of many systems.

Some Statistics relating to the Civil Service. *By* HORACE MANN.

The object of the paper was to supply a few facts and figures, so that outsiders might obtain a notion of the Civil Service. This was done under the heads of the numerical force of the service, the number of its departments, its nomenclature, remunerations, competitive examinations, schemes of examination, and limits of age. The paper concluded by the expression of the belief that it had made confusion conspicuous, and had indicated a picture of disorder, the natural result of a disintegrated service. The paper would fail of its design if it did not leave on the mind an impression, however faint, of the Civil Service as a chaotic mass of unorganized elements—an aggregate of separate departments, governed in many points by no common principles—with different kinds of work for the same kind of officer, and with varying nomenclature, varying remuneration, varying standards of examination, and varying practice as to the mode of appointment, all these variations being out of all proportion with the real variations existing in the subject-matter dealt with. What would be the appropriate remedy for some, at least, of the evils of this state of things was a question which must be reserved for another opportunity.

On the Influence of Occupation upon Health. *By* FRANCIS G. P. NEISON, *Jun., A.I.A.*

This paper was a brief summary of the results of the author's labours in connexion with the influence of various occupations upon health, as demonstrated by the following eight different combinations of occupations, exhibiting (1) the influence of factory occupations upon the health of those engaged in them; (2) the remarkable superiority in health of those engaged in domestic service over those in the same occupations not so situated; (3) the influence of underground occupations upon health; (4) the mortality among the professions; (5) the high mortality of those trades connected with animal food; (6) the mortality of occupations in connexion with railways; (7) the remarkable coincidence in the mortality of those working or engaged in communication with the different metals of iron, tin, lead, and copper, no matter how different, in other respects, the occupations might be, as iron-miners and ironmongers, for instance, and therefore the apparent influence that these metals have upon those connected with them; (8) and, lastly, the influence of drinks and stimulants upon health. Besides these combinations of occupation, many of the trades composing them were reviewed separately.

The special combination considered in the paper, however, was the third, as showing the low rate of mortality among iron- and coal-miners, in comparison with the same of tin, lead, and copper. This was accounted for principally by the very inferior ventilation in the latter three classes of mines, the temperature in one copper-mine mentioned being as high as 125° F. (51°·6 C.), whilst, at the same time, this great heat engendered the absorption of deleterious matter into the system, as regarded lead- and copper-miners, and without doubt greatly increases the noxious effects of their occupation. A table was also given showing the mortality of the different classes of miners for the forty years of life intervening between twenty-five and sixty-five years of age, from which it appeared that, whilst the same among iron- and coal-miners was at the rate of 13 and 14 deaths per 1000 living, among lead- and copper-miners it was as high as 20 and 24 per 1000.

Of occupations in general, all those connected with agriculture were shown to be by far the healthiest, these occupations, being those of labourers in rural districts, husbandmen, gardeners, and farmers; and their position as regarded health was in the order they are respectively placed. Sawyers, millers, shoemakers, weavers, labourers in towns and cities, and bricklayers were, in the order given, above the average in health, whilst shipwrights, servants, blacksmiths, carpenters and joiners, and whitesmiths were in the same degree below it. Butchers, and others engaged in connexion with animal food, such as fishmongers, poulterers, and provision-curers, were given as experiencing a very high mortality, influenced, most probably, by the inhalation of an air always more or less impregnated with animal matter, whilst at the same time the partaking of an undue amount of animal food would, no doubt, have a very deleterious effect. Chronic bronchitis, engendered by the large quantities of dust always pervading the occupation of stonemasons and those engaged in the earthenware manufacture, renders their calling very unhealthy, so that the mortality in these classes is high. In the factory occupations, independently of the diseases produced by special branches, the influence of bad ventilation is more or less prominent throughout. In no other class of persons, however, was the mortality shown to be so high as among those connected with drinks and stimulants, which class, it may be specified, comprised beersellers, wine and spirit merchants, publicans and licensed victuallers, and inn-keepers and hotel-keepers. In these occupations the effect was most marked at the younger ages, namely, twenty-five to forty-five; for in these *only* does the mortality at this period of life attain as high a rate as 17 per 1000 living; as, notwithstanding all the unhealthy and injurious influences to which those engaged in mining, the earthenware manufacture, and several of the most obnoxious factory occupations are exposed, in none is the mortality for this period of life above 14 per 1000, whereas in England and Wales generally it would be but 10 per 1000, and among labourers in rural districts and gardeners as low as at the rate of 6 per 1000 living.

In conclusion it was stated, as affording perhaps the best exemplification of the great influence of occupation upon health, that, if the mortality for the period of life under observation, namely, twenty-five to sixty-five, was compared with those two of the standard tables at present in use which may be supposed to represent the two extremes of longevity, the mortality would be confined between the two rates of 13 and 16·7 per 1000 living; yet, great as is the effect of occupation, the mortality in one class is over 188 per cent. more than that in another.

On the relation between Learning and Teaching. *By* Joseph Payne.

On the Extension of the Contagious Diseases Act.
By Henry J. Ker Porter, Esq., *M.R.I.A.*

The author's object was to prove the value of the Institution, and to bring before those who may hear or read this paper the importance of establishing Lock

hospitals where they do not exist at present, and of promoting, as far as possible, the extension of the Contagious Diseases Act for the benefit of the civil population in all large towns, its benefit having been fully proved by its operation in Naval and Military Stations.

Connected with the Female Hospital, an Asylum has been in existence for the last eighty years, affording to those desirous of its advantages a home for the present, and a prospect of useful and respectable employment for the future.

An extension of the female hospital took place in connexion with Government on the passing of the Contagious Diseases Act, and at present one hundred and twenty beds are at the disposal of the War Office, which defrays the expenses of the Government wards, the patients being sent from naval and military stations.

It has been officially stated that, since the operation of the Contagious Diseases Act, disease amongst the naval and military population has been reduced 50 per cent.

There are thirty beds in constant occupation at the Female Lock Hospital for ordinary patients.

At the Male Hospital, Dean Street, there are only fifteen beds for ordinary male patients; but it is hoped that the number may be increased to thirty, as there are many cases requiring constant care and treatment.

Statistics of the Lock Hospital.

Female Branch, Westbourne, Harrow Road.	Government Patients.	Ordinary Patients.	Total.
Number of Patients admitted in six months ending 31st December 1867	498	88	586
Number of Patients admitted in six months ending 20th June 1868	549	102	651
Total in twelve months	1047	190	1237
Of the above numbers received within twelve months,			
Those returned to their friends amounted to	7	5	12
Those who entered the Asylum	15	23	38
Those who went to other reformatories	5	11	16
Those who died	1	2	3
Number remaining in the Female Hospital on 30th June 1868	94	28	122

Male Branch, Dean Street, Soho.	Male Out-patients.		Female Out-patients.	
	New cases.	No. of attendances.	New Cases.	No. of attendances.
1867. Six months ending 31st Dec.	2036	11764	312	1875
1868. Six months ending 30th June	2397	11488	375	2383
	4433	23252	687	4258

Number of Out-patients and their Attendances since 1862.

	Male Patients.		Female Patients.	
	New cases.	Attendances.	New Cases.	Attendances.
1862	1174	5503	227	1178
1863	3159	17791	573	3707
1864	3998	22397	697	4365
1865	4087	22531	597	3632
1866	4227	22994	639	4087
1867	4216	21311	691	4330
1868	2397	11488	375	2383
	23258	124015	3799	23682

Attendances.

Total male new cases	23258	Male	124015
Total female new cases ...	3799	Female ...	23682
Total in nearly six years ...	27057		147697

Expense of medicine for each out-patient averages 1*s.* 6*d.* The expense of food per diem does not exceed 1*s.* in the Male Lock Hospital.

THE ASYLUM.

Admitted from July 1787, to 31st December 1867............		2043
Restored to their friends since commencement	409	
Placed in respectable services	616	
Left at their own request	926	
Died..	27	
Remaining in the Asylum 31st December 1867	65	
	2043	

On the Recent Improvements in Norfolk Farming. *By* C. S. Read, *M.P.*

Statistics of the Progress and Extermination of the Cattle Plague in Norfolk. *By* W. Smith, *M.R.C.V.S.*

On the Natural System of Coinage. *By* G. Johnstone Stoney, *M.A.*, *F.R.S.*

It is generally agreed that neither a silver standard for coinage nor a double standard of gold and silver is practicable on a wide scale or for a long time. An inquiry relating to coinage may therefore be based on the assumption that gold, whatever be its defects for the office, must be accepted as the real and sole standard of monetary value. And if we wish to reason with precision we must limit the statement, and say that *coined* gold is the standard of monetary value; since coined gold has, and must have unless overissued, a slightly higher market price than gold in the ingot.

Accordingly if we omit (as is the universal practice) the value of the alloy, gold coins have to one another values in the exact proportion of the weights of pure gold they contain. Thus the sovereign containing 732 centigrams of gold and the napoleon 580, no amount of manipulation would enable these coins to bear to one another any other ratio than that of 732 to 580, if we except the slight disturbance of this ratio which arises out of the depreciation of napoleons in England from their not being current coin.

As gold must be the ultimate standard of monetary value, it will be admitted to be of great and lasting importance that it should be made so in the form which is theoretically the simplest; in other words, *in that form which will inevitably prove most convenient in the long run.* Now the gram of pure gold in a coin has the requisite properties in the greatest attainable degree, and it happens to have a relation to existing coins which very much smooths the way for its introduction.

It has the requisite properties, because it is more natural to take *pure* gold as our standard than an alloy, just as it is most natural to take distilled water, and at a natural though unusual temperature, as our standard of specific gravity; and a little consideration will show that in both cases the same kind of permanent convenience will be the result. And if some mass of pure gold is to be our radix, it will at once be conceded that the quantity to be taken should bear the simplest attainable relation to the best system of weights. The gram of pure gold is therefore the NATURAL STANDARD.

Calling, then, the value of each gram of pure coined gold a monad, we may (in conformity with metrical nomenclature) form the following decimal series:—

Kilion, or kilogram of gold.	Decim, or decigram of gold.
Hekat, or hektogram of gold.	Cent, or centigram of gold.
Deka, or dekagram of gold.	Mil, or milligram of gold.
Monad, or gram of gold.	

The present silver and copper coins of Great Britain are of less than their nominal values, but the artificial values of these coins are kept up by their being made exchangeable with gold at the rate, fixed by statute, of 20 shillings to the sovereign; and by providing that silver and copper shall not be legal tenders for others than very small debts, so that no one can be forced to take a large quantity of the coins whose value is artificial. Now our existing coinage would be adjusted to the new one by slightly altering this artificial value, and legislating that after a certain date the sovereign shall be exchangeable for 20 shillings and 4 pence, and the half-sovereign for 10 and 2 pence. In this way the present nominal values of our existing silver and copper coins would be lowered to the extent of one-sixty-first part, which is less than half the change which would be required in some part of our coinage upon the adoption of either the pound and mil, or the five-franc scheme. Moreover, all contracts above one pound sterling would be wholly unaffected, and the relation of our silver to our copper coins would be undisturbed—the former of these being the condition which it is of most importance to observe in regard to large transactions, and the latter what is of most importance in regard to small.

After the change, the sovereign and half-sovereign would maintain their present values in virtue of their being gold: there would still be 7 monads and 32 cents in the sovereign, 3 monads and 66 cents in the half-sovereign. The penny would become precisely three cents, and the only British coins which would not fall in with the new ones would be the halfpenny of 15 mils and the farthing of $7\frac{1}{2}$ mils.

The copper coins proper to the new system would be the cent, the two-cent, and the three-cent or penny. In countries where smaller coins would be useful a five-mil piece (equivalent to one-sixth of a penny) might be added. In silver we should have the decim (about the size of a threepenny piece), the two-decim, the three-decim (value for tenpence), the five-decim, and the seven-decim. The half-crown is a nine-decim piece, and would add another coin of the series so long as it remains in circulation. The gold coins would be a seven-monad piece (about the size of a sovereign), a five-monad piece, and a three-monad piece, worth 100 pence. The monad is worth 33 pence and a cent. These coins are so selected that very small payments can be made by exchanging the larger coins, and that change of a large coin can be obtained in several different ways. These are both of them matters of much practical convenience. The gold coins should have the weights of pure gold they contain stated on them; for example, on the largest coin, "This coin contains 7 grams of gold." If the alloy for the three gold coins were $\frac{10}{11}$ths fine, they would weigh exactly 7·7 grams, 5·5 grams, and 3·3 grams. Accounts would be most conveniently kept in three columns of dekas, monads, and cents.

The pound and mil scheme has the advantage over that which is here advocated

that it would retain permanently the British pound and shilling; but at the same time it would do great violence to the values of our copper coins to force them into accordance with it: it would alter the relation between the existing silver and copper coins, the relation with which ignorant people have to deal; and above all it is arbitrary, and has little chance of becoming international or permanent. On the other hand a truly natural system, if once adopted by Great Britain, would inevitably make its way by its intrinsic merit among all sufficiently intelligent nations: just as the metrical system of weights and measures, after it was adopted by one great nation, is thus spreading, because it is not only a decimal system but natural also, *i.e.* one in which the measures of length, of surface, of capacity, and the weights are all related to one another in that way which is theoretically the simplest, in other words, in the way which is sure to prove practically the most convenient upon a sufficiently wide experience.

The proposal to make the dollar of five francs our unit is undoubtedly recommended by the circumstance that this dollar is a coin which agrees tolerably with some part of the existing coinage of several countries. But the advantage is transitory, and could only be secured at the price of fastening upon the world a coinage with the following three permanent defects:—

1. The dollar is a unit less adapted than a larger unit for estimating considerable sums, and at the same time its next decimal multiple, the ten-dollar piece, has been found inconveniently large.

2. It does not fall in with the metrical system of weights and measures, since the dollar of five francs, being the fourth part of a napoleon, contains 145 centigrams of gold. This defect entails many lasting disadvantages, and among them that—

3. On this account it would be exceedingly difficult, or rather quite impracticable, to keep it up to its value in the units of all nations.

There is only one course which will provide in the most effectual way that is attainable against the tampering with coinage of which the world has seen so many disgraceful examples, and that is to make the numerical relation between the weight of pure gold in a coin and the statement of its value the simplest possible; and there is but one way of doing this, viz. by taking the gram of pure gold as the unit of value. The number that represents the value of a coin would then bear the simplest relation that is possible to its fineness and its weight. Thus if the coin be $\frac{11}{12}$ths fine, weigh it in centigrams, subtract one-twelfth from the number of centigrams, and the remainder expresses the value of the coin in cents.

Finally, it would be well to keep in view that there is something which men will naturally regard with approval in the maintenance of a gold coinage at as high a standard of fineness as is compatible with wear.

It may reasonably be urged that it is by a regard to such feelings, and by considerations of durability and other valuable physical properties, that we should be principally guided in deciding what fineness shall be given to our coins. The coinage of Great Britain stands foremost in reputation over the world, a position partly won by its fineness, a position which does credit to us as a nation, and which we ought not lightly to resign. If we rendered our coinage a truly natural system by bringing it into harmony with the metrical system of weights and measures, so as to blend all (weights, measures, and coinage) into one consistent whole, we should be lasting benefactors of mankind in the same sense in which the French were when they gave existence to the metrical system—a system which, wherever it is adopted, is destined to benefit all posterity.

The best way to begin the introduction of the natural system of coinage would probably be to coin copper cents with the inscription, "This coin is worth one centigram of gold." The cent should pass current as one-third of a penny. This might be followed up by withdrawing the halfpenny, the farthing, and the threepenny piece from circulation, and by issuing a silver decim or ten-cent piece. This coin would be worth 3 pence and a cent, and should bear the inscription, "Worth one decigram of gold."

Classification of Labour. *By* F. Wilson.

MECHANICS.

Address by George Parker Bidder, *C.E., F.R.G.S., President of the Section.*

Gentlemen and Ladies,—In opening the proceedings of the Section, I have to offer a few remarks, which I do with the utmost diffidence, because this is the first occasion on which I have had the honour of being present at these Meetings. The leading object of the Association, as stated in the first paragraph of the programme, is to give a stronger impulse and a more systematic direction to scientific inquiry; and if I wanted an illustration of the manner in which this object is to be carried out, I should take it from the discussion upon Dr. Richardson's proposition, which was to the effect that the scope and object of this Section is to consider the application of the laws of mechanics to all mechanical operations for the benefit of the world in general, and of this country in particular. I may here say that we have at least this advantage, that the laws we seek to apply are undoubted and unquestioned, and that their best application must conduce to the benefit of mankind at large. I propose, on the present occasion, to refer briefly, and only very generally, to some of the topics which are at the present moment engrossing the attention of the public.

First I will deal with what I may call the great water question. In speaking upon this subject, I desire, at the outset, to congratulate the Section upon the presence at this Meeting of several of the highest and most eminent authorities upon this question, among whom I may mention Mr. Hawksley, whose name is associated with almost all the water-works of the United Kingdom, and with many foreign works of analogous character; and Mr. Bateman, who, among other works, has been the author of the great system by which the water of Loch Katrine is now conveyed to the city of Glasgow. I trust, therefore, that this Section will not disperse without having obtained that amount of useful and valuable information which these gentlemen are so capable of communicating. The entire question of water supply is one which has already assumed considerable proportions. It deals with the supply of water to the large cities and towns of this kingdom, with the utilization of that water for a variety of purposes connected with our manufactories, with the preservation of the beauty of our rivers, and the prevention of their pollution by the drainage of our towns and the refuse of our factories. Indeed a more beautiful and interesting subject can hardly engage the attention of engineers; and it may be said that it constitutes, in point of fact, the sensational literature of our profession. Whether we look to the circumstances and the constitution of the great rivers which flow through India, through America, and through the continent of Europe, or whether we turn to the smaller streams which circulate in this neighbourhood, we find one general law pervading the whole—a law which is well understood, and about which there can be no possibility of doubt. Nature, we know, always performs her functions by means of general laws, and we find these general laws always conduce to one result. We find that nature has provided, for the flow of water in our rivers, that the greatest rainfalls shall take place in the highest regions. The mountains receive the water from the clouds, and the water is brought down to the plains, where it is utilized for supplying our towns, for conveying our commerce from place to place, and, to a large extent, in some parts of the world, for irrigation. And we know that if this supply were properly preserved, irrigation might be considerably increased. The rainfall is conducted down the sides of the mountains, amidst rocks and through substances where it can do little harm, with the velocity due to the slopes of the region, and by the time it approaches the plains, it converges into streams which flow in an even and gentle course, conferring the greatest blessings upon mankind, although occasionally, but very seldom, committing some amount of ravage and harm. To show what nature effects in this way, I may state that in the Himalayas the quantity of water which falls from the clouds amounts to something like 400 inches per annum. In some of the mountains of Cumberland the rainfall has been gauged to the extent of 200 inches, and in this neighbourhood it is said to be very little

over 20 inches per annum. The late Mr. Robert Stephenson told me that upon one occasion in the Andes, the rainfall amounted to as much as 8 inches within the short space of an hour. This is a question assuming so great importance that I think this Association ought to use all its power and influence to induce the Government to aid it in these investigations, by which alone the engineer can be guided in the application of the laws to which I have alluded. I think that the quantity of water which falls along the whole course of our rivers should be gauged, that the rainfall at different intervals should also be measured, and that there should likewise be meteorological observations, for the purpose of ascertaining the condition of the atmosphere under which these rainfalls occur. I think that if these observations were persevered in for a few years, a mass of facts might be collected which might, by the aid of the great and extensive knowledge of my friends now present, be applied to the permanent benefit of this country.

The remarks I have just made may, to some extent, be illustrated by circumstances connected with the rivers in this immediate neighbourhood. As you are aware, the rivers Wensum and Yare converge at a point a little below this city. The river Waveney joins them a little below Reedham, and the river Bure flows into them at a point not far from Yarmouth, the whole of the water being conveyed thence through the harbour into the sea. There is no doubt that formerly there was in this locality a great estuary open to the ocean, but the travelling sands which form the dunes upon this coast seem to have confined that water within the narrow channel which falls into the ocean at Gorlestone. I believe that at one period the Waveney flowed through Mutford lock, and that a dam was erected there by the advice of some Dutch engineers, with a view to prevent the incursion of the sea, which doubtless inflicted upon the upper lands much greater injury than could be caused by the freshwater floods. But, be this as it may, if you trace the Wensum from its course down the valley, flowing at a gentle rate, and affording nourishment to a considerable tract of country between Norwich and Yarmouth, you will find that the entire flow of the water is maintained by a fall of something like 4 or 5 inches in the mile. This circumstance is undoubtedly attended with great advantage to the neighbourhood. In the first place, the waters of the Yare are free from any large amount of deposit, while the velocity of the stream is so slight that it does not have the effect of destroying or injuring the banks, which are composed of a soft material, and the river being deep, enables a large amount of commerce to be carried on between Yarmouth and Norwich by those beautiful craft, the wherries, which navigate these waters. Such is the facility afforded by the river for the conveyance of traffic, that these wherries maintain to this moment an active competition with the railway which runs between this place and Yarmouth. Near Yarmouth we have the entire body of water belonging to this district converging at the head of Breydon, and all the circumstances connected with these waters are subject to laws which we can estimate with perfect certainty. But beyond the point I have alluded to they come in contact with the tide; and here commences a disturbing element, upon which a great variety of opinion is maintained, and which has, I am aware, led to much litigation.

Yarmouth has also this further natural condition, that being surrounded by a vast amount of sand, which forms the roadstead, the result is that, although on both sides of the coast, at Aldborough and on the estuary near Lynn, the tide rises from 16 to 18 feet at springs, nevertheless it only rises some 5 feet at Yarmouth. The consequence is that the tidal scour at Yarmouth is very much reduced, and the effect is so much modified that it occasions a large outlay in maintaining even the present depth of water over the bar, inadequate as that may be. But if the range of the tide through the port of Yarmouth had corresponded with that upon each side at the places I have mentioned, it is a question whether its effect upon the estuary of the river would not be of the most disastrous character. My own opinion is that such would be the effect; but my more immediate object is to call attention to the tidal influences, combined with the fresh water from the land, in the maintenance of the bar at Yarmouth. Upon the question of how much is due to the land floods, and how much to the flux and reflux of the tide, there is great difference of opinion among philosophers and engineers. It is, indeed, a difficult question; but I think it is one that ought to be grappled with, and one

the solution of which this Association ought to keep in view. I think that by the collection of records of accurate and well-established facts, we might be enabled to arrive at something like a sound practical conclusion upon it; and this leads me to a suggestion as to what this Association might do in the matter. Let us take the case of the Yarmouth estuary in particular. If before coming to Norwich notice had been given to the Commissioners at Yarmouth and the authorities at Lowestoft, I have no doubt that the Association might have been supplied with a series of tidal observations and charts showing the condition of the harbour at different periods, due to the various works which had been executed. This information might have been rendered of extreme utility. Next year you meet at Exeter, near the estuary of the Exe, which is, to some extent, analogous to the locality of which I have been speaking; and I would suggest that this Association should apply to the authorities at Exmouth for such information as they possess with reference to their harbour.

The result of the convergence of the rivers at Yarmouth was to give to that port a monopoly of the whole trade of this district; and the effect of that monopoly was, as in the case of most other monopolies, though doubtfully beneficial to the port of Yarmouth, certainly not advantageous to this city or to the neighbouring district. So much had this been felt that, forty-three years ago, the late Sir William Cubitt obtained an Act of Parliament for the construction of the harbour of Lowestoft, and I think the capital required to carry out that undertaking was chiefly provided by this city. But the capital was insufficient for the execution of the works upon such a scale as would enable the harbour to be used to any great extent, and until the railway Company took the matter in hand, and made Lowestoft what it is, the full advantages which Yarmouth could give to this district were never realized. The Yarmouth authorities then set about improving their harbour, reducing the charges, and conferring other advantages, of which this city has reaped the benefit. And now you have two harbours within a few miles of each other, constituted on totally different principles. You have that of Yarmouth, maintained by the flow of the land waters of the Yare, the Waveney, the Wensum, and the Bure; and you have that of Lowestoft, which is maintained entirely by dredging, there being no land water, with the exception of the small quantity which is allowed to pass through during the process of locking the vessels. It is my belief that the result of a thorough investigation of this question, conducted by competent persons, would show that the land waters conduce but little, if at all, to the maintenance of the port of Yarmouth, and that they might be allowed, to some extent, to pass through to the sea in other directions, by which means a large area of land would be effectually drained, other land irrigated, an unfailing supply of water rendered available for the towns, and the harbours of Yarmouth and Lowestoft be maintained and rendered accessible to vessels of larger burthen. This is, however, a topic of purely local importance.

There is another topic, which is of worldwide celebrity, to which I must call attention. It is one of vast interest to science, and may throw a light on some other questions. I allude to an undertaking which has excited considerable attention, from its pretensions to connect the Mediterranean with the Red Sea by a canal across the Isthmus of Suez. That canal is now approaching completion. I believe that every man of liberal mind would desire to see that great work successfully completed. The canal passes in its course through what is known as the Bitter Lakes, which have a depression of some 40 feet below the level of the Red Sea. The depression is perfectly dry, and is covered by a stratum of salt, which is used by the natives. This depression must be filled with water from the Red Sea, from which it is distant about eighteen miles. The most interesting circumstance connected with this undertaking is, the filling and the maintenance of the Bitter Lakes with water. The area of the lakes has been stated to be about 300 square miles; but it is given by the French at five hundred millions of square yards, which amounts to about 150 square miles, or 100,000 acres. Now the rate of evaporation of water in Egypt is about 1 inch per diem. Consider how much this would be over an area of five hundred millions square yards. It will, I believe, amount to three hundred and sixty millions of cubic feet per diem, which means something like two hundred and fifty thousand feet per minute. The

contents of the sectional area of the canal are between 6000 and 7000 square feet, and the amount required to supply the evaporation would require a velocity in the canal of 40 feet per minute. Now, as I have said, this water must come from the Red Sea, which is depressed by the northerly winds prevailing during about nine months out of twelve, and is raised by the southerly winds, the variation being at times as much as 7 feet,—ordinarily about 5 feet. The mean level of the water in the canal can therefore only be maintained at a level below that of the extreme depression of the Red Sea, in addition to the inclination necessary for the flow of the water into the Bitter Lakes, to provide for the evaporation.

If this Association would endeavour to obtain information in reference to all the phenomena which may attend the filling of these great lakes from the Red Sea, it would be doing considerable service to science. The enormous evaporation of one inch per diem is equal to a rainfall of 365 inches per annum, and it cannot but exercise some influence on the atmosphere of the surrounding district. This, I say, ought to be carefully watched, and the most accurate observations ought to be constantly made.

I have now to approach a question which has excited a great amount of public attention and discussion. It is a subject which will come home to every man in this country. I do not know how far my remarks may come into collision with some of the papers which are to be read, but I offer them entirely on my own authority. I allude to the state of our Navy. I may begin by saying that, however satisfactory the general condition of our navy may be to the departments, it must be admitted that in many essentials its condition is not satisfactory to the country at large; and I hope I may be enabled to point out to you in what way public opinion may be beneficially brought to bear upon this important subject. I feel certain I shall carry you all with me in saying that we in this country have but one desire with regard to our navy, and that is, that, whatever may be the cost to the nation, we should have the very best ships which the ocean can carry, and which machinery can propel. I am speaking in the presence of men of great professional skill and experience, men who have conducted ships through every sea throughout the world, and among them I may mention the name of Admiral Sir Edward Belcher. I think that he will agree with me in saying that the qualities of a vessel in reference to her speed and steadiness ought to be thoroughly ascertained before she is built. There is no merchant who builds a steamer for the conveyance of passengers or goods who does not clearly lay down the object which the ship is intended to accomplish, and who does not require that this should be considered by the builder. I say that the same rule ought to apply in the Royal Navy, and that before any vessel of war is built her speed should be in the first instance determined. And here I may say that when I speak of speed, I do not mean speed as taken in the trials at Stokes Bay; I refer to sea-going speed, which depends upon many other qualities than those which a trial at Stokes Bay can possibly determine. The evolutions of a fleet, to be effective, must be conducted with precision and certainty. This cannot be attained unless the speed of all the ships of a squadron be nearly the same. Of course, you cannot obtain exact uniformity, but you may approach it very nearly. But to have a fleet in which some ships will steam at the rate of 14 knots, some at the rate of 12 knots, and others at the rate of only 10 knots, is very much like endeavouring to get up a pack composed of all the dogs in a town, including the swiftest greyhounds and the very commonest curs that can be met with. The speed of a vessel ought to be the first element of consideration; for it is useless to carry guns which may sweep another vessel out of the water if the ship carrying those guns can only steam at the rate of 10 knots an hour, while the vessel she is pursuing is enabled to go 14 knots. The next point is to utilize the speed. I will not attempt to enter into the question of broadside and turret ships, but I may say that whatever may be the difficulty in broadside ships of getting fine lines for the head and stern, this difficulty ought not to exist in turret vessels. Having settled the battery, it ought to be subject to as little disturbance as possible; but the question of the relative utility of a gun, whether on a fixed platform or on a moveable one, is too obvious to need further comment. At present, however, it is

unfortunately the case that when we send a ship to sea we do not know how much she will roll. I am now speaking in the presence of great mathematicians, and I have no hesitation in saying that the laws which regulate the rolling of a ship are as well known and determined as any laws upon which we act. Therefore I say that the extent to which a ship will roll when sent to sea ought to be ascertained before we are put to the expense of building a new ship at a cost of a quarter of a million of money. I am, of course, aware that whatever may be the certainty with which science may determine the conditions of the rolling of a ship, and the degree of steadiness she may exhibit under canvas, another element will come in which will defy mathematics, and that is, the different form and action of the waves. Further than this, in specifying the conditions of the rolling of a ship, mathematics will not determine what may be the exact motion of any particular vessel. It cannot do this, but what it will do may be readily ascertained. For instance, if we compare one vessel with another of the same class, knowing the conditions of the two with regard to the distribution of weights and so on, we shall be able to determine whether one particular ship will roll more than another. If you have a vessel of 40 feet beam, or of 60 feet beam, she must be compared with another vessel of the same breadth of beam. There can be no doubt that any one seeing the 'Great Eastern' steaming down channel where there was not sufficient sea to cause her to roll, would imagine her to be incapable of that action; but in reality when she is subject to the heavy swell of the Atlantic her rolling is said to be "a caution"—in fact she will roll in the Atlantic Ocean to an extent that is almost intolerable. In short, what I mean is, that in all future vessels their rolling should be fixed in reference to some standard vessel of a similar class.

Whilst on this subject I may mention a circumstance which occurred about two months since, and which I admit did much astonish me. I was talking to a friend about the experiments then making at Shoeburyness, when a third gentleman joined us, and the conversation turned upon ships. I expressed the opinion that it was not creditable to the Admiralty that, in the construction of the Navy, ships were sent to sea before it was known how much or how little they would roll; and I referred to a statement, which appeared in the 'Times,' as to the discreditable condition of the fleet during the cruize to Lisbon. The third gentleman I have mentioned emphatically denied the correctness of the reports that had appeared, in reference to the rolling of the ships; and he added, "I have letters from the captains of those vessels, stating that they were as firm as rocks, and that there had not been any occasion when they could not dine in the cabins without requiring any protection for the dishes." I then said, "Do you mean to say that the official statements which have appeared, and which have remained uncontradicted, are untrue?" The reply that I received was, "What I have stated is what I have had from the captains themselves." The gentleman who made this statement having quitted us, I inquired who he was, and was surprised to learn that I had been listening to Mr. E. J. Reed, the chief constructor of the Navy. Now if there are in existence private documents entirely at variance with those furnished for the information of Parliament and the public, either the Admiralty must be leaving the public in the dark, or they must have been themselves deluded.

Now next to stability in a vessel is sea-worthiness, and the ability of a ship to go easily through a very heavy head sea depends very much on the disposition of the weights near her head and stern. If you try the sailing qualities of two vessels in smooth water, you will probably find that vessel A may go two knots an hour faster than vessel B; but if you take them out into a head sea, you may possibly find that vessel B goes two knots an hour faster than vessel A. Every time a vessel makes a plunge into the sea the amount of power taken out of her is immense; and I maintain that the trials of vessels which take place at Stokes Bay are pure delusions. The trials of all our iron ships ought to take place at sea, and I think they ought to be conducted by men of experience and of good scientific knowledge, who are altogether independent of the Government or any other influence; and until this is done we shall not be able to apply that check to the constructive department of the Admiralty which I think the country ought to exercise. The next question with regard to ships is that of the amount of protection. In my opinion

the question whether we should give more or less protection to our vessels by means of armour plates must be subordinate to the purposes to which the ships are to be applied as floating batteries. I say that you ought, in the first place, to obtain a fast ship and one that will carry her battery so steadily as to make it most useful and effective, and she ought to be able to go through a head sea; then, subordinate to these requisites, protect her as well as you can. It is of no use to have a ship so protected and overweighted that she becomes inefficient as a moveable fort.

Before concluding my remarks on ships I would say a few words on propulsion, upon which subject there is a paper, and in reference to which Dr. Fairbairn has a report to make. You must all be aware that within the last year or two a new mode of propulsion by the emission of water has been introduced, and that the experiment has cost the country about £40,000. It has been broadly asserted that there are no means of obtaining from that mode of propulsion more than 25 per cent. of the power applied. I say, therefore, that before experiments of this sort are tried, the Government, or at all events this Association, ought to investigate the subject in order to see whether the new mode be the most economical application of power or the most wasteful that can be adopted. The matter is not to be worked out by experiments with ships which only go eight knots an hour in smooth water. Admiral Sir Edward Belcher assures me that the speed attained was ten knots, and that she beat the other vessel against which she was tried; to which I would reply that she might easily accomplish that, as the other was one of the worst designed ships in the Navy.

This leads me to another question in which we are all interested, and that is our coast defences. We have all been frightened for some years by the statement that we may be attacked by an invading force, and that we are or have been peculiarly open to the assaults of an enemy, and therefore ought to take the best possible measures for protecting our shores. The theory of this no one can deny, but the mode in which the protection is to be afforded is another thing. I happen to belong to a Volunteer Staff Corps whose especial business it is to consider this question and to advise the Government upon it. The first question we had to consider was the defence of the east coast of England, and especially of the coast of this district. It is obvious that there is no part of our coast which is so vulnerable as this particular division; that there is no part of the country which offers the same inducements to an enemy to attack it as this district. How this district is proposed to be defended, and what are the operations to be undertaken in providing for that defence, are matters of confidence between the corps I represent and Her Majesty's Government; but I have the satisfaction of being able to say that we have come to this conclusion—that, easily as the coast in this district might be attacked, it would by the adoption of judicious means be just as easily defended, and this, too, without the erection of those ponderous forts which have been constructed on the southern coast. But it would have been expected that no sooner were the Armstrong and the Whitworth guns invented, and the power and precision with which projectiles could be fired against any fort or vessel were understood, than the authorities would have turned their serious attention to the question, and would have applied the strictest scientific investigation to the new condition of things. Indeed from the moment when the Armstrong and Whitworth guns were produced the days of embrasures were numbered. Any man who knows anything of the question will agree with me that he is safer in the open country than behind an embrasure. In the open country he affords but one small point of attack, and the chances of his being hit are comparatively small, but beside a gun inside the embrasure of a fort, if a shot strikes within that space he is subject to casualty from splinters. The introduction of the new mode of gunnery marked an epoch at which the whole method of fortification should have been reconsidered; and if this had been done I feel sure that we should not have had to regret the construction of many large useless forts, not however including some of older date, for the design of which it is impossible to discover who is responsible.

A Commission has been instructed to report on the soundness of construction of these forts; I would venture to suggest that another Commission should be appointed to report on their military efficiency.

You have all read the accounts of the vast experiments that have lately been made in gunnery. I believe Dr. Fairbairn has been connected with those experiments on the shields designed for the purpose of resisting the heaviest modern artillery. I will not for a moment deny the value of these experiments; but I must say that, in my opinion, they would have been more valuable if they had been based on the well-known laws of the resistance of metals of the same quality to impact due to weight and velocity. I think that improvement in the structure of guns would have been advanced with more certainty if the action of gunpowder upon the projectile had been clearly ascertained and defined. It is perfectly certain that gunpowder when exploded cannot act with less power than sixty tons upon the square inch; it is also certain that unless that power be immediately reduced we have no gun which it will not destroy; but the fact is that the moment the projectile moves, the enormous expansion of the powder is reduced with such rapidity that the metal has not time to yield and break before the pressure is removed and the danger is gone. This shows that the kind of metal you use, whatever its tenacity and hardness, should be capable of yielding to a certain extent, without absolutely breaking; but it is quite certain that this sort of action is of such a nature that if it be continued to a certain extent it must lead to the destruction of the gun, and that the question as to the life of a gun is only one of how many charges may be fired from it before it is absolutely destroyed. I say that the whole question of the mechanical action of the gunpowder gases should be absolutely determined and settled, and that it ought to be clearly understood by those who are engaged in designing guns. If they go on without this knowledge they are merely proceeding at "hap-hazard," and are groping in the dark.

The improvement of the communication between England and the Continent is now daily exciting more and more attention. Admirably as the service is conducted, under existing circumstances, still the horrors and delays of the middle passage, across the Straits of Dover, will, so long as they continue, restrict free intercourse with the Continent. Indeed, until a traveller can reach his destination, at Paris or Brussels, in the same carriage in which he started from London, this great desideratum cannot be said to have been attained.

There are now two projects, more or less, before the public,—one for bridging the Channel, and the other for tunnelling beneath it. Before analyzing these projects I would make one general observation, viz. that any project involving an outlay (inclusive of interest during progress) of from forty to fifty millions sterling, and requiring from forty to fifty years for its execution, cannot with reason be entertained.

With regard to the Bridge project, the latest proposition would appear to be to span the channel by a viaduct consisting of openings of three thousand feet each. The platform must of necessity be upwards of two hundred feet above the level of the sea. The piers would be erected on islets founded in a depth of water of thirty fathoms. Now, bearing in mind that to bridge the Thames in the most economical manner involves a cost of about £125 per lineal foot, and applying this as a standard, contrasting the facilities in the one case with the obvious enormous difficulties and contingencies in the other, the relative cost of the latter must greatly exceed four times that of the former; the minimum cost, therefore, of the channel viaduct cannot be taken at less than £500 per lineal foot, which at once brings the cost up to fifty millions sterling, without taking into account current interest. With these remarks we may dismiss the Bridge question.

A recent article in the 'Times' describes the Tunnel project: the main tunnel is to be constructed at such a depth below the bottom of the channel as, it is hoped, would enable a stratum to be reached which would be impervious to infiltration. Nevertheless there is some uncertainty on this point. It is proposed to commence by driving a trial heading at a cost of two millions sterling. The estimated cost of the main tunnel was stated at, I believe, eight millions, raising the total estimated cost to ten millions. Without going into all the details of construction, I will only allude to the two main features—the driving of the heading, and the completion of the main tunnel.

It is obvious that the heading can only be driven from the two ends; and as-

suming that the stratum is found to be so favourable as to admit of an uninterrupted daily progress of two to three yards being made at each face (a rate of progress which is beyond my experience), twenty years will be absorbed in this trial only, and the two millions to be expended will become nearly three millions, by the addition of interest. Assuming the trial heading to be completed, and that arrangements had been made for working the main tunnel from as many as ten faces (four intermediate points and the two ends), and assuming the same absence of contingencies and an unbroken period of peace, a progress of 20 yards per week is the greatest that can be anticipated; but for the purpose of my argument I will assume the progress to be 30 lineal yards per week. Upon this basis an additional period of twenty-five years will be required to complete the main tunnel. By that time the three millions expended in forming the heading will, by the addition of interest, have reached the sum of seven millions, and the eight millions spent in the main tunnel will, for the same reason, have become twelve millions: thus, without taking into account innumerable unforeseen contingencies necessarily attendant on such a work, the outlay may be taken at twenty millions sterling, and the time occupied at not less than forty-five years. The carrying on the tunnel works at four intermediate points through a heading of such enormous length is clearly impracticable; three or four shafts in mid-channel would therefore become essential. Let us consider what the construction of a shaft in mid-channel would involve. It has to be founded in water of the depth of 30 fathoms, then to perforate a water-bearing stratum of uncertain thickness; then let us see what work this shaft has to do. From the very nature of the locality (a sea much vexed by storms) there must be a barrack for the workmen, space for the materials of construction, and a pier for shelter and for discharging the vessels laden with stores and materials. I must therefore confess that, to my mind, although such a work cannot be assumed to be mechanically impossible, it would appear to be commercially and nationally infeasible. If my views are correct, this great international problem still remains for solution.

There is one other subject to which I will allude, and in the presence of so distinguished a man as Mr. Siemens, who has attained so eminent a position as an electrician, and who is now, I am happy to say, engaged in the completion of the Indo-European Telegraph, while he is at the same time applying his great powers to other subjects, I could hardly close my remarks without saying a few words on electricity, with which he has for many years been connected; and it is more especially interesting, as the Electric Telegraph was first practically applied by the late Mr. Robert Stephenson and myself to working the single line of railway, as originally constructed, between this city (Norwich) and Yarmouth, and about the same time it was adapted, at our suggestion, to working the stationary engine system on the Blackwall Railway. The experience derived from these adaptations induced me, at a later period, to originate commercial telegraphy, by establishing the Electric and International Telegraph Company in 1845–46. A question which has been greatly agitated in this country is that of the telegraph to the East, which is undoubtedly an undertaking of extreme utility. There is a company seeking to continue the telegraph to and through Egypt by way of the Red Sea, and they urge the great advantage it would be in making us more independent of foreign influences; but a chain is always estimated by the strength of its weakest link, and there is one weak link in this proposed telegraphic chain, and that is the passage through Egypt. This latter point demands grave consideration. A telegraphic line established *viâ* Gibraltar, the Cape of Good Hope, and Ceylon would be 3000 miles longer than the direct route, and would no doubt cost a considerable additional sum; but if such a line were established, the only potentate with whom we should have to contend for possession of that telegraph would be Old Neptune. I wish our friend every success in the operation he is carrying on, but I should be better pleased to see his name associated with the successful completion of an integral line of telegraph to India.

There is another subject to which I would refer, and that is the question of technical education. I think that education of this kind ought to be directed more especially to the branch which the student intends to pursue in after life. You would not give the same education to the engineer that you would give to the

artist or to the agriculturist; but all technical education should be accompanied by a sound knowledge of the elementary laws of mechanics. Indeed I would have this knowledge instilled into the mind of the student over and over again until it became almost a part of his nature; and I make this observation on an experience of five and forty years. I have known some of our greatest engineers and most eminent philosophers make the most discreditable errors through not having been thoroughly acquainted with the elementary laws of mechanics, which, I repeat, ought to form the basis of all technical education*. Before any engineer would entrust a young man, however well educated, with any work of the smallest importance, he would require that he should have had some practical acquaintance with the branch to which that work belongs. I think, also, that the theory on which the technical education of the Royal Engineers is conducted ought to be modified, and that they ought to have a certain amount of practical apprenticeship in the great operations they have to carry on; as, for instance, in the construction of forts, and especially before taking charge of gun and other factories. I am well aware that Mr. Whitworth, who has made such a princely endowment for technical education, feels strongly on this point, and he has expressed his conviction that if this principle were adopted vastly greater economy and efficiency for the public service would be attained.

Looking at the achievements of Sir William Armstrong and Mr. Whitworth in revolutionizing the construction of artillery, we have an example of what can be effected by the concentration of the minds of accomplished mechanicians upon special subjects.

In conclusion I may say that, beyond all these things, we should never lose sight of that pursuit to which a powerful Commission has directed its attention—I refer to the application of machinery to the economical working and ventilation of mines; and this being accomplished, the economic use of the products of those mines ought next to engage attention, whether as applied to the working of our manufactories and the turning of our spindles, to cheering the poor man in his humble home, or to propelling through the water those ironclads which represent the might and genius of this great country—the might they may represent, the genius they caricature.

On the Mechanism for utilizing and regulating Convict Labour. By C. J. Appleby.

On R. W. Thomson's Patent Road Steamer. By Professor Archer.

An Improved Machine for Drawing-off, Measuring, and Cutting Cloth and other Materials for Manufacturing Purposes. By C. Blyth.

* As a further illustration of the want of elementary knowledge, I would allude to the Aëronautical Society for promoting aërial locomotion. In this Society are to be found the names of men of considerable scientific and mechanical reputation; but it may be easily shown how vain, in any practical sense, is the pursuit upon which they are engaged.

Let us see what amount of power would be requisite to propel a balloon capable of supporting the weight of one person only.

For this purpose I will assume a perfectly calm atmosphere, also that a gas can be obtained with sufficient tension, but without weight, and that the balloon can be made of a material so light that its weight may also be omitted from the calculation.

With these favourable and impracticable conditions, it would require a balloon of 16 feet diameter to support the weight of a man in our atmosphere.

To propel this at the speed of 20 miles per hour (about one-half of that of an express train) would require an engine of at least five horse-power.

It may, however, be said that a spherical form is not the best adapted for displacing the air; on the other hand, I would observe that this only holds in dead calms—that when the course of the balloon is across the current of the atmosphere the resistance would be increased in a much greater ratio.

On London Sreet Tramways. By H. Bright.

The author said the London omnibuses were notoriously mismanaged; and when it was remembered that there were 600 of these vehicles in London, each capable of carrying, on an average, twenty-three passengers, the question became an important one. There could be little doubt that a judicious system of street tramways, or horse railways, would supply a great and rapidly growing demand, which could not be met by steam locomotion on the ordinary railway, where the trains could not work like omnibuses, taking up passengers at every moment when required, but must run through from station to station. Street tramways had proved a success wherever they had been judiciously tried, andwould doubtless yield an enormous profit if laid down in London and other large towns. They were extensively used in America and Canada, and had been adopted at Copenhagen and the suburbs of Paris; while it was proposed to apply them to Berlin, Brussels, and Vienna. The objection which might be urged against the interference of tramways with the ordinary traffic would be met by taking the many good and available lines afforded by back streets, taking care to bring the line at certain points into close proximity to the main traffic. The system he proposed to adopt was somewhat similar to that which was at present in use in Manchester and Geneva, the vehicle being kept on the track by means of a wheel, which the driver could at pleasure drop into or lift up from a grooved rail in the centre of the track. The formation of the lines for the carriage-wheels was peculiar, there being a slope with a depression of only one inch for each wheel, which would be so made as to fit the wheel-ways, while the depression will be so slight that it could not obstruct the progress of any ordinary vehicle. The vehicle would be enabled to turn the sharpest curves, and would carry forty-eight passengers, exclusive of the driver and conductor. It was proposed, by an efficient system of breaks, with a carefully devised scheme of compensation for the horses, to enable the driver to stop the vehicle at any moment.

On the substitution of Hand- for Shoulder-guns, illustrated by an explanatory exhibition of an Elevator Hand-gun made on the Breech-loading Principle. By E. Charlesworth, *F.G.S.*

On the Advisability of obtaining a Uniform Wire-Gauge. By Latimer Clark, *C.E.*

This was in continuation of a paper on the same subject last year. The writer showed that there were many different gauges now in use, and that it had become almost a usual thing for each manufacturer to set up his own gauge. The evils of this system were obvious, and were much felt by wire-drawers, as well as by engineers. If a gauge were authorized by the British Association, he believed it would be universally adopted by engineers, manufacturers, and wire-drawers. The gauge proposed by the writer differed very little from that now in use, and known as the Birmingham gauge; and he suggested that the question was one upon which the Association might appoint a Committee.

An Improvement in Watering Roads. By W. J. Cooper.

Improvements in the Packing of Boats, Lifeboats, and Pontoons. By G. Fawcus.

This was a continuation of a paper read on a former occasion, specially showing how the author's system of packing and stowing of boats was applicable, not only to ordinary ship's boats, but to lifeboats and to pontoons.

On the Unsatisfactory Character of Coroners' Inquests consequent on Steam-Boiler Explosions. By LAVINGTON E. FLETCHER.

It appears that since the commencement of 1835 up to the 31st of May last there occurred in different parts of the kingdom as many as 464 explosions, by which 789 persons were killed and 924 injured; and these are not all, as in the earlier years the records are not complete. It may be stated, in round numbers, that about fifty steam-boiler explosions occur on an average every year, resulting in the loss of seventy lives. In the author's opinion, derived from a very extended experience, whatever may be the precise circumstances of each case, the cause of every one may be given in one word, viz. *neglect*, while the simple preventive is *care*. The author proceeded to say, let every coroner be empowered and instructed, when holding an inquiry on a boiler explosion, to call in two competent and perfectly independent scientific engineers to investigate the cause of the explosion, and report to the jury. These engineers should visit the scene of the explosion, examine the fragments of the boiler, attend to the inquest, hear the evidence given by parties concerned in the charge of the boiler, and aid the coroner in conducting the inquiry; while, in addition, they should report to him, either jointly or severally, on the cause of the explosion, and accompany their report with suitable sealed drawings of the exploded boiler, showing its original construction and the lines of fracture as well as the flight of the parts, as far as they can be ascertained. The inquest to be open to the public, under the control of the coroner, and also to the press, both scientific and general, so that the entire proceedings may have as wide a circulation as possible. A full account of the inquiry, including the engineers' reports, accompanied with the sealed drawings to be printed and deposited at the Patent Office, and to be accessible to both the purchase and inspection of the public, as is at present the case with the specification of patents. Also a report of each inquiry to be sent to the members of both Houses of Parliament as issued. Such a course, he thought, would stimulate coroners to make searching and full investigations; and if at the outset incompetent engineers were selected by the coroner, the publicity given to their proceedings, as recommended above, would bring them under the criticism of the press and general engineering public, which it is thought might be relied on as a corrective. If full investigations were brought to bear upon boiler explosions, and those persons who produce them by working old worn-out boilers were fairly brought to the bar of public opinion, and compelled, when necessary, to compensate the widow and orphan for the results of their negligence, the mystery of boiler explosions would soon be dispelled, and their occurrence put a stop to. He considerd this plan superior to any government inspection, which led to the fettering of trade and destroyed responsibility.

On the Irrigation of Upper Lombardy by New Canals to be derived from the Lakes Lugano and Maggiore. By P. LE NEVE FOSTER, Jun., *C.E.*

The author, after referring to the high pitch of perfection to which irrigation in Lombardy has been carried, pointed out that, although the lower part of Lombardy is well watered by existing canals, the whole tract of country to the north of Milan, extending to the foot of the hills of Varese and the Brianza, is too high to be watered by them, and is almost unirrigated. The author then described the technical details of a scheme undertaken by Signori Villoresi and Meraviglia, by which it is proposed to irrigate the higher lands by canals from the Lake Lugano and the lower lands by canals from Lago Maggiore, this Lake being situated at too low a level to water the whole region, while the supply from Lugano is not more than sufficient to water half the whole district. Permission has been obtained from the Swiss Government to store up the flood-waters of Lugano, and regulate their discharge for use in droughts. The same system will be adopted in reference to Lago Maggiore, and works for this purpose, consisting of dams, gates, and locks, will be erected in connexion with both lakes. The waters will be distributed by principal canals—five in number, secondary canals, communal canals, and private canals. The total number of the works to be constructed, such as locks (of which there will be forty-seven), bridges, aqueducts, siphons, &c., will be about 260, and the

canals are estimated to supply 8000 horse-power for mills &c., and to irrigate and thus improve the agriculture of 400 communes. The cost is estimated at two millions and a quarter sterling. One of the most remarkable features of the scheme is the manner in which it is proposed to raise the capital: *Consorzii*, or societies of consumers of water, are to be promoted by the local authorities. In this manner, the provinces, communes, and other corporate bodies bind themselves to take a certain quantity of water, either by payment of a fixed sum down or by annual payments, which payments they are able to guarantee from the receipts they will derive from the sale of the water to the various consumers, or, if necessary, from their other sources of revenue, and the capital is raised on bonds issued on this basis. The concession is granted for ninety years, after which the works become the property of the State. The works will probably be commenced in the course of the autumn.

Description of a Ventilating Fireplace, with Experiments upon its Heating Power as compared with that of ordinary Fireplaces. By Capt. D. Galton, *C.B., F.R.S.*

By means of very simple arrangements, described by the author, but which are unintelligible without diagrams, the rooms are heated by an open fireplace of an ordinary character, whilst the heat which would otherwise be lost in passing up the chimney is utilized in warming a current of fresh air from without, brought in for the supply of the room. The author stated that it was now largely used in barracks, and its introduction had been attended with marked benefit both for the health and comfort of the troops. Upwards of 5000 had been erected in various places, and were now in use, and it was no longer an experiment. The stove was not expensive, and the arrangements could be adapted to existing buildings.

The Broads of East Norfolk, having reference to the Water-supply, Stowage, and Drainage. By R. B. Grantham, *C.E.*

The author commenced by alluding to the derivation of the word "Broad" from the Anglo-Saxon Bradan or Bradene, meaning to make broad. Breydon Water, near Yarmouth, has undoubtedly the same derivation. As Inspector of Drainages under the Land-Drainage Act, he had visited the neighbourhood to report upon some applications for drainage, and while there he was struck by the existence of such large and singular bodies of water, of which he could find no similar instance except on the opposite coast of Holland.

The particular object of the paper was to point out the uses to which these "Broads" might be put as a means of water-supply and storage to towns and villages, and also to show that the improvement of the surrounding land might be effected by combined drainage systems. The supply of water to Yarmouth from Ormesby, Rollesby, and Filby Broads (about 500 acres) was referred to as an instance of water-supply, and the improvements carried out at Martham, Somerton and Winterton, and Beccles were mentioned as cases of combined drainage systems.

Geologically considered, this part of Norfolk consists of posttertiary, alluvial, lacustrine, and estuarine deposits, contorted sand-beds, Upper and Lower Boulder-clays, laminated beds of clay resting on Norwich Crag, which lies partly upon the Chalk, which is about 400 feet thick, and dips towards the south-east, and partly upon the London Clay. The waters conforming to the slope of the Chalk are discharged into the sea at Yarmouth. The collection of the Museum at Norwich contains the characteristic fossils of the different formations.

According to history, it was shown that the sea at one time flowed up to Norwich, and enabled ships to sail up there.

The author then proceeded to describe the general character of the valleys of the Yare, the Bure, and the Waveney, giving their respective areas; the Yare containing 533, Bure 338, Waveney 339 square miles, making a total of 1210 square miles.

He then explained what he conceived to be the origin of the "Broads." The

sea receding from these valleys left wide channels in the low parts of the country which became receptacles for the drainage. The growth and decay of vegetation and the detritus brought down by the streams gradually narrowed the channels, and confined them to the present course of the rivers. Large spaces were, however, left occupied by the water, which are now termed "Broads." They are thirty in number, and vary in size from 578 to $11\frac{3}{4}$ acres.

The mean rainfall in the country for seven years is 24·41 inches.

The depths of the "Broads" were stated as varying considerably. Some of the bottoms of them are on a level with the sea at low water at Yarmouth.

All the "Broads" are supplied by the streams from the minor valleys and by springs, and there is no doubt that they are of great service in times of flood, when they store up the flood-waters and prevent them from overflowing the lands below; and it is in the capacity of reservoirs that all these "Broads" might be made most useful.

With regard to the drainage, the author was of opinion that the marshes which surround them might be treated in a similar manner to those at Winterton and at Hemesby. The injurious effects of marshes upon health are well known, and he therefore thought the reclamation would remove the cause.

An Improved Centrifugal Pump. *By* J. H. Gwynne.

On the Noted Slate-veins of Festiniog. *By* S. Jenkins.

On some Points affecting the Economical Manufacture of Iron. *By* John Jones, *F.G.S.*

The author estimated the production of pig iron in Great Britain at 4,500,000 tons per annum, and the make of finished iron at about 3,000,000 tons. The author adduced these statistics to show the immense issues involved in the improvements he wished to notice. The author then referred to the economical application of fuel in the iron-manufacture, more particularly in the finished iron processes, and remarked that the newer blast-furnace plant left little to be accomplished in the economical use of fuel, except in utilizing the waste products given off in coking the fuel. In puddling, however, great waste of fuel went on, and two modifications of the ordinary puddling-furnace were to be noticed as calculated to save from 20 to 25 per cent. of fuel, and to consume all the smoke usually produced. The Wilson furnace, in its most recently improved form, consisted of a sloping chamber, into which the fuel was fed at the top; and the volatile matters generally forming smoke were reduced by passing over the incandescent mass of fuel further along the chamber. The air for combustion was delivered into the furnace in a heated condition, and a steam-jet was delivered underneath the grate, by means of which the formation of clinkers was avoided. The Newport furnace, Middlesborough, had a chamber constructed in the ordinary chimney-stack; and in this were placed a couple of cast-iron pipes, with a partition reaching nearly to the top. These pipes were heated by the waste gases from the puddling-furnace, and through them the air required for combustion was forced by means of a steam-jet, and was thus delivered in front of the grate in a highly heated condition. These furnaces, of which a considerable number were in operation at the Newport works, effected a saving of at least 25 per cent. in fuel. The structural modifications would involve comparatively little outlay, and the saving to be effected would recoup that outlay in a single year. The economy represented by applying the new plans to the whole iron trade would amount to about 1,500,000 tons of coal per annum. The author next proceeded to describe the manufacture of iron by what is termed the Radcliffe process, which had been for some time in operation at the Consett Ironworks, Newcastle. The puddled iron, which was usually rolled into rough bars, straightened and weighed, allowed to get cool, then cut up, piled, heated, rolled into blooms, reheated, and, finally, rolled into finished iron, after a complicated series of operations, was, by the new method, finished off by a con-

tinuous and simple process. Five or more puddled balls were put together into a large bloom, under a very heavy steam-hammer, shingled down into a bloom, passed for a short time through a heating-furnace, and rolled off into finished iron not more than half an hour after the iron left the puddling-furnace. Specimens of iron made by the process were exhibited. A great saving in the cost of manufacture was represented by this process in all departments of the manufacture of finished iron; and it was calculated that a saving of 1,500,000 tons of coal alone would result from the general application of this system. Particular stress was laid upon the fact that, in carrying out this process, no extensive or expensive alteration of existing works was required, and a saving of from $3\frac{1}{2}$ to 4 cwt. of puddled iron would be secured upon each ton of finished rails or plates now turned out, the cost of making malleable iron being reduced to a very considerable extent. The importance of the whole question, in a national point of view, was also dwelt upon.

On the recent Progress of Steel Manufacture. By Ferdinand Kohn.

The author had, at the previous Meeting at Dundee, drawn attention to a process of manufacturing steel upon the open hearth of a Siemens's furnace by the mutual reaction of pig iron and wrought iron upon each other—a process which had at that time commenced to gain ground upon the Continent, but had not been brought into commercial practice in this country. This process, which had been named the Martin process by its inventors, Messrs. E. and P. Martin, in Paris, should, in justice to both the inventors to whom its success was due, obtain the name Siemens-Martin process.

The Siemens-Martin process had within this last year been brought into operation in this country at the Newport Steel Works, in Middleborough-on-Tees, belonging to the well-known firm of Messrs. Samuelson and Co.; and it had been worked with great regularity and with very satisfactory results, employing in a very considerable proportion the puddled iron from the Cleveland district as the raw material. The Siemens-Martin process realized the old idea of melting wrought iron in a bath of liquid pig iron, and thereby converting the whole mass into steel. The principal elements of its successful operation, and the points which distinguish it from all previous unsuccessful attempts, are the high temperature and the neutral or non-oxidizing flame of the regenerative gas-furnace, and the method of charging the decarburized iron into the bath of pig iron in measured quantities, which are added at regular intervals, so that each following charge in melting or being dissolved increases the quantity and the dissolving power of the bath until the stage of complete decarburization is arrived at. The operation is then completed by the addition of pig iron containing manganese; and by regulating the quantity of that addition, any desired degree of hardness could be obtained with certainty. The prime cost of the Siemens-Martin steel did not exceed that of Bessemer steel, made from hematite iron in this country. The author did not apprehend any danger for the Bessemer process from the competition of this new mode of steel manufacture, which, working with different raw materials, could only assist and stimulate the Bessemer process and the spread of steel manufacture in general.

On the Abrading and Transporting Power of Water. By T. Login, *F.R.S.E.*

On the Necessity for further Experimental Knowledge respecting the Propulsion of Ships. By Charles W. Merrifield, *F.R.S.*

The author began with a short review of what was already known on the subject of the law of the resistance to which a ship was subjected by its having to force its way through the water. The author showed that although there was a general consent that the resistance varied, with a certain degree of approximation, according to the law of the square of the velocity, yet there was abundant proof that that law was inexact, and that the nature and causes of this discrepancy, although much discussed, were still in need of experimental determination. He

considered that the first requisite was to have the direction and velocity of the currents of water which accompany a ship's motion determined by actual observation. For this purpose he submitted to the Section a rough scheme of experiments, which, however, he wanted to get corrected by the experience of a Committee of the Association. He suggested that a vessel of the corvette class should (at separate times) be towed, and also driven by her own screw, instruments being used to measure both the power employed, the speed of the vessel, and the velocity and direction of the accompanying water, at various rates of speed. He pointed out serious difficulties in ascertaining the direction of the currents of water, and was unable to suggest for this purpose anything better than direct vision. The author exhibited certain instruments for assisting the eye in looking through the disturbed surface,—one of them being a common water-glass, a simple trumpet with a sheet of plate glass at the bottom, which was dipped below the water, the other being Arago's scopeloscope. He also described an electrical log, patented by M. Anfonso, of Mende. But he thought all these things required further consideration. He proposed to apply for a Committee of the Association to discuss the subject, with a view of considering what experiments might best be made; and if the Committee were of opinion that satisfactory results might be expected from such experiments, then to memorialize the Admiralty to detail vessels and officers for the purpose of carrying them out in the course of the summer.

On Dynamite, a recent Preparation of Nitro-glycerine, as a Blasting Agent. By A. Nobel.

The author stated that by mixing nitro-glycerine and powdered silica in the proportions of 75 per cent. of the former to 25 per cent. of the latter, a substance was obtained which, while it retained all the valuable properties of nitro-glycerine for blasting, was no longer dangerous, inasmuch as it could be handled freely, and did not explode by fire alone, or when accidentally subjected to percussion. He instanced experiments lately made at Glasgow and Merstham. A box containing about 8 lbs. of dynamite (equal in power to 80 lbs. of gunpowder) was placed over a fire, where it slowly burned away; and another box with the same quantity was hurled from a height of more than 60 feet on the rock below, no explosion ensuing from the concussion sustained. It appeared that the explosion when required was produced by means of a percussion-cap, which acted both by percussion and by fire, the combination of the two producing the effect, whilst neither alone was effective. The value of the material as a blasting agent appeared to be very great; and if it be as safe as the author believes, it cannot fail to be of great assistance both to the engineer and the miner.

On a Probable Connexion between the Resistance of Ships and their Mean Depth of Immersion. By Prof. W. J. Macquorn Rankine, *C.E., LL.D., F.R.S.*

The author, after referring to previous researches of his own and of Mr. Scott Russell in relation to waves, stated that the object of his paper was to call the attention of the British Association, and especially of the Committee on steamship performance, to the probable existence of an element in the resistance of ships hitherto neglected, viz. that every ship is accompanied by waves whose natural speed depends on the virtual depth to which she disturbs the water*, and that consequently, when the speed of a ship exceeds that natural speed, there is probably an additional term in the resistance depending on such excess. The author suggests that suitable observations and calculations should be made in order to discover its amount and its laws. Amongst observations which would be serviceable for that purpose might be mentioned the measurement of the angles of divergence of the wave-ridges raised by various vessels at given speeds, and the determination of the figure of those ridges, which were well known to be curved; and amongst the results of calculation the *mean depth of immersion* as found by dividing the volume of displacement by the area of the plane of floatation, and that

* Let k be the virtual depth of disturbance; the natural speed of the waves is $\sqrt{gk}$.

not only for the whole ship, but for her fore and after bodies separately, it being probable that the virtual depth of uniform disturbance, if not equal to the mean depth of immersion, is connected with it by some definite relation. In an appendix the author gave the results of three observations he had been able to make; and, few as they had been, he thought they were sufficient to prove the existence of waves whose speed of advance depended on the depth to which the vessels disturbed the water. The connexion between these waves and the resistance remained for future investigation.

Auxiliary Railway for Turnpike Roads and Highways passing through Towns. By W. THOROLD.

The author stated that he only required a single line of rails, which he proposed should be laid on one side of the road, out of the way of the ordinary traffic. By an arrangement of grooved wheels under the centre of the engine and carriages, so constructed that they will be capable of maintaining their grip upon curves of 20-feet radius, thereby giving the vehicles the power of turning corners with the greatest facility, the inventor thinks his principle peculiarly adapted to locomotion through new countries, and for passing through ravines, or up and down the sides of mountains, up any gradient not exceeding 1 in 12. He proposed to propel the carriages by steam-traction engines, although they might also be drawn by horses or other beasts of burden. The adhesion of the traction-wheels could be regulated to any weight, and by the application of a special apparatus the engine might be made to lift the traction-wheels out of a soft place. The cost of the new railway he estimated at about £500*l.* per mile.

The arrangements employed for the distribution of Water to towns and dwellings in the Middle Ages. By the Rev. Professor WILLIS, *F.R.S.*

On the Proper Form of Projectiles for Penetration under Water. By JOSEPH WHITWORTH, *LL.D., F.R.S.*

The author exhibited a photograph showing the actual effect produced on an iron plate in an experiment made by him with three descriptions of projectiles. The iron plate shown in the photograph is 50 in. long, 13 wide, 1·2 in. thick, and was immersed in water 39 in. deep. The gun used was the 1-pounder, from which all the former experiments were made previous to the first penetration of 4-in. armour from his 70-pounder rifled gun in October 1858. The angle of depression of the gun was 7° 7″, the distance which the projectile passed through the water from the point of entering it to the bull's-eye is 80 inches. No. 1 projectile is Whitworth steel, and of the flat-headed form always advocated by the author for use at sea. The photograph showed that it was not deflected by passing through the water. No. 2 shot, with hemispherical form of head, was deflected, and struck 9½ in. above the bull's-eye. No. 3 projectile is of white cast iron, commonly called the Palliser, or chilled shot, and it struck 19 in. above the bull's-eye, its conical form of head causing it to rise quickly out of the water. The advantages of No. 1 projectile are, first, its power of penetration when fired even at extreme angles against armour plates; secondly, its large internal capacity as a shell; thirdly, the capability of passing through water and of penetrating armour below the water line. The No. 3 projectile is advocated by Major Palliser, on account of its cheapness and its power of penetration, which latter quality, however, depends upon its being fired at a near approach to right angles against armour plates; its adoption is also supported by the Director of Ordnance (at the War Office) and the President of the Ordnance Select Committee. The author regretted that he had for so many years been so frequently obliged to differ in opinion on mechanical subjects with these gentlemen. His objections to this projectile are, first, that when it is fired at any considerable angle against an armour plate its form induces it to glance off, and the brittleness of the metal causes it to break up; and it is to be observed that in naval actions oblique fire is the rule, and direct fire is the rare exception; second, that the brittleness and consequent weakness of the metal necessitate a greater thickness of the sides, and reduce its internal

capacity as a shell; and, third, that its form renders it useless for penetration under water. If the First Lord of the Admiralty would have a few rounds fired at sea from the Whitworth 7-in. gun and the Woolwich 7-in gun, with each kind of projectile, at a range of, say, 500 yards, and at various angles, against an armour plate fixed on the side of an old ship, the result would show which description of projectile was the best adapted for the service. This power of penetration under water, with the flat-fronted projectile, was first brought by Mr. Whitworth under the notice of the War Office and the Admiralty in 1857, simultaneously with the introduction of armour plating; and, by desire of the late Lord Hardinge, who

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Relative progress of the

Year.	Royal.	Statistical.	Royal Astronomical.	Chemical.	Geological.	Antiquaries.
1830.	734	......	......	......	617	849
1831.	753	......	......	......	650	867
1832.	748	......	......	......	649	838
1833.	747	......	......	......	716	483
1834.	770	......	......	......	745	832
1835.	793	......	......	......	774	837
1836.	793	......	324	......	810	828
1837.	798	......	335	......	807	810
1838.	789	402	346	......	831	769
1839.	809	418	345	......	855	820
1840.	812	448	250	......	862	828
1841.	827	458	340	......	865	784
1842.	825	468	349	......	868	780
1843.	830	451	341	......	883	764
1844.	824	461	337	......	875	736
1845.	828	458	344	......	883	650
1846.	841	412	365	......	894	642
1847.	*828	412	365	190	897	656
1848.	812	412	344	224	899	584
1849.	808	412	388	236	888	564
1850.	798	413	412	249	825	546
1851.	777	412	418	245	864	537
1852.	767	432	441	241	866	524
1853.	761	437	445	......	871	569
1854.	745	437	450	247	884	619
1855.	729	353	464	261	875	623
1856.	720	382	447	256	868	623
1857.	715	384	449	269	877	634
1858.	706	367	436	277	872	635
1859.	691	359	435	302	907	644
1860.	673	357	435	365	922	647
1861.	661	373	454	352	940	651
1862.	660	374	480	444	969	†652
1863.	657	365	491	468	1033	664
1864.	655	357	484	497	1092	648
1865.	639	358	505	519	1117	657
1866.	626	364	511	539	1149	651
1867.	617	366	516	551	1185	629
1868.	600	371	528	518	1204	622

* In 1847 the new rule was introduced by which not more than 15 Fellows are elected annually, exclusive of special elections of Peers and Members of the Privy Council.

was then Commander-in-Chief, a 24-pounder howitzer was rifled and was sent, with some projectiles, for trial to Portsmouth. The experiment was perfectly successful. Capt. Hewlett, of the ship 'Excellent,' says, in his report to the Admiralty, January 25th, 1858, "The penetration into wood at this depth under water has, I believe, never before been obtained." In 1864 the matter was brought before the Armstrong and Whitworth Committee, and an experiment was made from the 'Stork' gunboat with a Whitworth 70-pounder gun. On that occasion the projectile penetrated at 3·75 feet under water the side of the 'Alfred,' which was of oak 24 in. thick.

Learned Societies (*see p.* 173).

Geographical.	Actuaries.	Architects.	Engineers.	Medical and Chirurgical.	Entomological.	United Service Institution.
......	......	......	......	......	......	......
......	......	......	......	......	......	1437
......	......	......	......	......	......	2699
......	......	......	......	333	......	3341
......	......	......	200	......	115	3768
......	......	......	......	......	......	4155
......	......	......	252	329	......	4069
......	......	......	......	393	......	4164
......	......	......	......	389	......	4175
......	......	......	375	407	......	4186
......	......	......	424	427	193	4257
......	......	......	482	450	......	4243
......	......	......	525	492	......	4127
......	......	......	560	494	195	4078
671	......	......	552	575	......	3968
684	......	......	582	538	......	3988
695	......	......	600	550	......	4031
668	......	......	610	547	......	4017
627	......	......	626	538	......	3947
601	......	......	664	558	......	3970
607	......	......	681	578	119	3998
611	......	228	716	578	......	3188
610	244	225	745	589	......	3078
727	264	227	750	606	......	3251
804	245	248	773	611	134	3171
842	212	253	787	619	......	3131
907	177	263	797	627	148	3204
1039	129	275	835	622	......	3168
1206	144	284	857	628	159	3246
1302	156	293	894	629	......	3344
1354	147	312	930	631	......	3518
1631	155	338	945	630	166	3689
1250	167	348	1000	642	167	3797
1909	184	371	1040	634	164	3847
1987	198	386	1095	626	143	3902
2036	203	411	1203	640	175	3895
2097	220	440	1339	630	191	3891
2102	228	467	1433	641	200	3823
2150	221	498	1694	665	208	3812

† The number of Fellows of the Society of Antiquaries was by a Statute of 1862 restricted to 600.

On Patent Monopoly as affecting the Encouragement, Improvement, and Progress of Science, Arts, and Manufactures. By HENRY DIRCKS, *C.E., LL.D., &c.*

The object of this paper was to show that patent monopoly had for centuries been conceded to inventors, but that up to the early part of the eighteenth century inventors were not bound to describe any particular kind of machine or process, and that the first descriptive specification dates no earlier than 3rd October, 1711. Especial notice was taken of the abuses of the system during the reign of Queen Elizabeth, and the successive improvements in Patent Law from the accession of James I. to the present time. As inventors can have no protection beyond a patented or a secret process, it is shown that secret inventions are a truer monopoly than patent right affords, while at the same time secrets are open to the practice of every species of deception. Tables were exhibited of Patent Inventions chronologically arranged, from March 1617 (14 James I.) to October 1852, when the first great improvement took place in reducing patent fees to at least one-third of their usual previous cost; and reign by reign patent progress bore no comparison with what is made in that of the present reign. There were only 4 patents per annum during the reign of James I., 62 per annum in that of George III., and not above 297 per annum up to 1853, or twenty-three years of Victoria, whereas they now rate at 3000 per annum. By other tables was shown the number of patents from the eighteenth to the nineteenth century obtained by various eminent patentees, all contributing to show the decided advantages reaped by arts, science, and manufactures through improved liberal patent laws.

INDEX I.

TO

REPORTS ON THE STATE OF SCIENCE.

INDEX II.

TO

MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

[*An asterisk (*) signifies that no abstract of the communication is given.*]

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The Published Reports of Proceedings at the Meetings of the Association may be obtained by *Members* on application to Messrs. Taylor & Francis, Printing Office, Red Lion Court Fleet Street, London, E.C., at the following prices, viz.—Reports for 1849–67, at two-thirds of the Publication Price; and for the purpose of completing their sets, any of the first seventeen volumes, *of which more than* 100 *copies remain*, at one-third of the Publication Price.

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CONTENTS:—Prof. Airy, on the Progress of Astronomy;—J. W. Lubbock, on the Tides;—Prof. Forbes, on the Present State of Meteorology;—Prof. Powell, on the Present State of the Science of Radiant Heat;—Prof. Cumming, on Thermo-Electricity;—Sir D. Brewster, on the Progress of Optics;—Rev. W. Whewell, on the Present State of Mineralogy;—Rev. W. D. Conybeare, on the Recent Progress and Present State of Geology;—Dr. Prichard's Review of Philological and Physical Researches.

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PROCEEDINGS OF THE THIRD MEETING, at Cambridge, 1833, *Published at* 12*s*.

CONTENTS:—Proceedings of the Meeting;—John Taylor, on Mineral Veins;—Dr. Lindley, on the Philosophy of Botany;—Dr. Henry, on the Physiology of the Nervous System;—P. Barlow, on the Strength of Materials;—S. H. Christie, on the Magnetism of the Earth;—Rev. J. Challis, on the Analytical Theory of Hydrostatics and Hydrodynamics;—G. Rennie, on Hydraulics as a Branch of Engineering, Part I.;—Rev. G. Peacock, on certain Branches of Analysis.

Together with papers on Mathematics and Physics, Philosophical Instruments and Mechanical Arts, Natural History, Anatomy, Physiology, and History of Science.

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CONTENTS:—H. G. Rogers, on the Geology of North America;—Dr. C. Henry, on the Laws of Contagion;—Prof. Clark, on Animal Physiology;—Rev. L. Jenyns, on Zoology;—

Rev. J. Challis, on Capillary Attraction;—Prof. Lloyd, on Physical Optics;—G. Rennie, on Hydraulics, Part II.

Together with the Transactions of the Sections, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTH MEETING, at Dublin, 1835, *Published at* 13*s*. 6*d*.

CONTENTS:—Rev. W. Whewell, on the Recent Progress and Present Condition of the Mathematical Theories of Electricity, Magnetism, and Heat;—A. Quetelet, Aperçu de l'Etat actuel des Sciences Mathématiques chez les Belges;—Capt. E. Sabine, on the Phenomena of Terrestrial Magnetism.

Together with the Transactions of the Sections, Prof. Sir W. Hamilton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SIXTH MEETING, at Bristol, 1836, *Published at* 12*s*.

CONTENTS:—Prof. Daubeny, on the Present State of our Knowledge with respect to Mineral and Thermal Waters;—Major E. Sabine, on the Direction and Intensity of the Terrestrial Magnetic Force in Scotland;—J. Richardson, on North American Zoology;—Rev. J. Challis, on the Mathematical Theory of Fluids;—J. T. Mackay, a Comparative View of the more remarkable Plants which characterize the neighbourhood of Dublin and Edinburgh, and the South-west of Scotland, &c.;—J. T. Mackay, Comparative Geographical Notices of the more remarkable Plants which characterize Scotland and Ireland;—Report of the London Sub-Committee of the Medical Section on the Motions and Sounds of the Heart;—Second Report of the Dublin Sub-Committee on the Motions and Sounds of the Heart;—Report of the Dublin Committee on the Pathology of the Brain and Nervous System;—J. W. Lubbock, Account of the Recent Discussions of Observations of the Tides;—Rev. B. Powell, on determining the Refractive Indices for the Standard Rays of the Solar Spectrum in various media;—Dr. Hodgkin, on the Communication between the Arteries and Absorbents;—Prof. Phillips, Report of Experiments on Subterranean Temperature;—Prof. Hamilton, on the Validity of a Method recently proposed by G. B. Jerrard, for Transforming and Resolving Equations of Elevated Degrees.

Together with the Transactions of the Sections, Prof. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SEVENTH MEETING, at Liverpool, 1837, *Published at* 16*s*. 6*d*.

CONTENTS:—Major E. Sabine, on the Variations of the Magnetic Intensity observed at different points of the Earth's Surface;—Rev. W. Taylor, on the various modes of Printing for the Use of the Blind;—J. W. Lubbock, on the Discussions of Observations of the Tides;—Prof. T. Thomson, on the Difference between the Composition of Cast Iron produced by the Cold and Hot Blast;—Rev. T. R. Robinson, on the Determination of the Constant of Nutation by the Greenwich Observations;—R. W. Fox, Experiments on the Electricity of Metallic Veins, and the Temperature of Mines;—Provisional Report of the Committee of the Medical Section of the British Association, appointed to investigate the Composition of Secretions, and the Organs producing them;—Dr. G. O. Rees, Report from the Committee for inquiring into the Analysis of the Glands, &c. of the Human Body;—Second Report of the London Sub-Committee of the British Association Medical Section, on the Motions and Sounds of the Heart;—Prof. Johnston, on the Present State of our Knowledge in regard to Dimorphous Bodies;—Lt.-Col. Sykes, on the Statistics of the Four Collectorates of Dukhun, under the British Government;—E. Hodgkinson, on the relative Strength and other Mechanical Properties of Iron obtained from the Hot and Cold Blast;—W. Fairbairn, on the Strength and other Properties of Iron obtained from the Hot and Cold Blast;—Sir J. Robison, and J. S. Russell, Report of the Committee on Waves;—Note by Major Sabine, being an Appendix to his Report on the Variations of the Magnetic Intensity observed at different Points of the Earth's Surface;—J. Yates, on the Growth of Plants under Glass, and without any free communication with the outward Air, on the Plan of Mr. N. J. Ward, of London.

Together with the Transactions of the Sections, Prof. Traill's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTH MEETING, at Newcastle, 1838, *Published at* 15*s*.

CONTENTS:—Rev. W. Whewell, Account of a Level Line, measured from the Bristol Chan-

nel to the English Channel, by Mr. Bunt;—Report on the Discussions of Tides, prepared under the direction of the Rev. W. Whewell;—W. S. Harris, Account of the Progress and State of the Meteorological Observations at Plymouth;—Major E. Sabine, on the Magnetic Isoclinal and Isodynamic Lines in the British Islands;—D. Lardner, LL.D., on the Determination of the Mean Numerical Values of Railway Constants;—R. Mallet, First Report upon Experiments upon the Action of Sea and River Water upon Cast and Wrought Iron;—R. Mallet, on the Action of a Heat of 212° Fahr., when long continued, on Inorganic and Organic Substances.

Together with the Transactions of the Sections, Mr. Murchison's Address, and Recommendations of the Association and its Committees.

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Contents:—Rev. B. Powell, Report on the Present State of our Knowledge of Refractive Indices, for the Standard Rays of the Solar Spectrum in different media;—Report on the Application of the Sum assigned for Tide Calculations to Rev. W. Whewell, in a Letter from T. G. Bunt, Esq.;—H. L. Pattinson, on some Galvanic Experiments to determine the Existence or Non-Existence of Electrical Currents among Stratified Rocks, particularly those of the Mountain Limestone formation, constituting the Lead Measures of Alton Moor;—Sir D. Brewster, Reports respecting the two series of Hourly Meteorological Observations kept in Scotland;—Report on the subject of a series of Resolutions adopted by the British Association at their Meeting in August 1838, at Newcastle;—R. Owen, Report on British Fossil Reptiles;—E. Forbes, Report on the Distribution of Pulmoniferous Mollusca in the British Isles;—W. S. Harris, Third Report on the Progress of the Hourly Meteorological Register at Plymouth Dockyard.

Together with the Transactions of the Sections, Rev. W. Vernon Harcourt's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TENTH MEETING, at Glasgow, 1840, *Published at* 15*s*.

Contents:—Rev. B. Powell, Report on the recent Progress of discovery relative to Radiant Heat, supplementary to a former Report on the same subject inserted in the first volume of the Reports of the British Association for the Advancement of Science;—J. D. Forbes, Supplementary Report on Meteorology;—W. S. Harris, Report on Prof. Whewell's Anemometer, now in operation at Plymouth;—Report on "The Motion and Sounds of the Heart," by the London Committee of the British Association, for 1839–40;—Prof. Schönbein, an Account of Researches in Electro-Chemistry;—R. Mallet, Second Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at various temperatures, upon Cast Iron, Wrought Iron and Steel;—R. W. Fox, Report on some Observations on Subterranean Temperature;—A. F. Osler, Report on the Observations recorded during the years 1837, 1838, 1839, and 1840, by the Self-registering Anemometer erected at the Philosophical Institution, Birmingham;—Sir D. Brewster, Report respecting the two Series of Hourly Meteorological Observations kept at Inverness and Kingussie, from Nov. 1st, 1838 to Nov. 1st, 1839;—W. Thompson, Report on the Fauna of Ireland: Div. *Vertebrata*;—C. J. B. Williams, M.D., Report of Experiments on the Physiology of the Lungs and Air-Tubes;—Rev. J. S. Henslow, Report of the Committee on the Preservation of Animal and Vegetable Substances.

Together with the Transactions of the Sections, Mr. Murchison and Major E. Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE ELEVENTH MEETING, at Plymouth, 1841, *Published at* 13*s*. 6*d*.

Contents:—Rev. P. Kelland, on the Present state of our Theoretical and Experimental Knowledge of the Laws of Conduction of Heat;—G. L. Roupell, M.D., Report on Poisons;—T. G. Bunt, Report on Discussions of Bristol Tides, under the direction of the Rev. W. Whewell;—D. Ross, Report on the Discussions of Leith Tide Observations, under the direction of the Rev. W. Whewell;—W. S. Harris, upon the working of Whewell's Anemometer at Plymouth during the past year;—Report of a Committee appointed for the purpose of superintending the scientific cooperation of the British Association in the System of Simultaneous Observations in Terrestrial Magnetism and Meteorology;—Reports of Committees appointed to provide Meteorological Instruments for the use of M. Agassiz and Mr. M'Cord;—Report of a Com-

mittee to superintend the reduction of Meteorological Observations;—Report of a Committee for revising the Nomenclature of the Stars;—Report of a Committee for obtaining Instruments and Registers to record Shocks and Earthquakes in Scotland and Ireland;—Report of a Committee on the Preservation of Vegetative Powers in Seeds;—Dr. Hodgkin, on Inquiries into the Races of Man;—Report of the Committee appointed to report how far the Desiderata in our knowledge of the Condition of the Upper Strata of the Atmosphere may be supplied by means of Ascents in Balloons or otherwise, to ascertain the probable expense of such Experiments, and to draw up Directions for Observers in such circumstances;—R. Owen, Report on British Fossil Reptiles;—Reports on the Determination of the Mean Value of Railway Constants;—D. Lardner, LL.D., Second and concluding Report on the Determination of the Mean Value of Railway Constants;—E. Woods, Report on Railway Constants;—Report of a Committee on the Construction of a Constant Indicator for Steam-Engines.

Together with the Transactions of the Sections, Prof. Whewell's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWELFTH MEETING, at Manchester, 1842, *Published at* 10*s*. 6*d*.

CONTENTS:—Report of the Committee appointed to conduct the cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—J. Richardson, M.D., Report on the present State of the Ichthyology of New Zealand;—W. S. Harris, Report on the Progress of Meteorological Observations at Plymouth;—Second Report of a Committee appointed to make Experiments on the Growth and Vitality of Seeds;—C. Vignoles, Report of the Committee on Railway Sections;—Report of the Committee for the Preservation of Animal and Vegetable Substances;—Lyon Playfair, M.D., Abstract of Prof. Liebig's Report on Organic Chemistry applied to Physiology and Pathology;—R. Owen, Report on the British Fossil Mammalia, Part I.;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—L. Agassiz, Report on the Fossil Fishes of the Devonian System or Old Red Sandstone;—W. Fairbairn, Appendix to a Report on the Strength and other Properties of Cast Iron obtained from the Hot and Cold Blast;—D. Milne, Report of the Committee for Registering Shocks of Earthquakes in Great Britain;—Report of a Committee on the construction of a Constant Indicator for Steam-Engines, and for the determination of the Velocity of the Piston of the Self-acting Engine at different periods of the Stroke;—J. S. Russell, Report of a Committee on the Form of Ships;—Report of a Committee appointed "to consider of the Rules by which the Nomenclature of Zoology may be established on a uniform and permanent basis;"—Report of a Committee on the Vital Statistics of large Towns in Scotland;—Provisional Reports, and Notices of Progress in special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Lord Francis Egerton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTEENTH MEETING, at Cork, 1843, *Published at* 12*s*.

CONTENTS:—Robert Mallet, Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at Various Temperatures, upon Cast Iron, Wrought Iron, and Steel;—Report of the Committee appointed to conduct the cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Sir J. F. W. Herschel, Bart., Report of the Committee appointed for the Reduction of Meteorological Observations;—Report of the Committee appointed for Experiments on Steam-Engines;—Report of the Committee appointed to continue their Experiments on the Vitality of Seeds;—J. S. Russell, Report of a Series of Observations on the Tides of the Frith of Forth and the East Coast of Scotland;—J. S. Russell, Notice of a Report of the Committee on the Form of Ships;—J. Blake, Report on the Physiological Action of Medicines;—Report of the Committee on Zoological Nomenclature;—Report of the Committee for Registering the Shocks of Earthquakes, and making such Meteorological Observations as may appear to them desirable;—Report of the Committee for conducting Experiments with Captive Balloons;—Prof. Wheatstone, Appendix to the Report;—Report of the Committee for the Translation and Publication of Foreign Scientific Memoirs;—C. W. Peach, on the Habits of the Marine Testacea;—E. Forbes, Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology;—L. Agassiz, Synoptical Table of British Fossil Fishes, arranged in the order of the Geological Formations;—R. Owen, Report on the British Fossil Mammalia, Part II.;—E. W. Binney, Report on the excavation made at the junction of the Lower New Red Sandstone with the Coal Measures at Collyhurst;—W.

Thompson, Report on the Fauna of Ireland: Div. *Invertebrata*;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Earl of Rosse's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS of the FOURTEENTH MEETING, at York, 1844, *Published at* £1.

CONTENTS:—W. B. Carpenter, on the Microscopic Structure of Shells;—J. Alder and A. Hancock, Report on the British Nudibranchiate Mollusca;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—Report of a Committee appointed by the British Association in 1840, for revising the Nomenclature of the Stars;—Lt.-Col. Sabine, on the Meteorology of Toronto in Canada;—J. Blackwall, Report on some recent researches into the Structure, Functions, and Economy of the *Araneidea* made in Great Britain;—Earl of Rosse, on the Construction of large Reflecting Telescopes;—Rev. W. V. Harcourt, Report on a Gas-furnace for Experiments on Vitrifaction and other Applications of High Heat in the Laboratory;—Report of the Committee for Registering Earthquake Shocks in Scotland;—Report of a Committee for Experiments on Steam-Engines;—Report of the Committee to investigate the Varieties of the Human Race;—Fourth Report of a Committee appointed to continue their Experiments on the Vitality of Seeds;—W. Fairbairn, on the Consumption of Fuel and the Prevention of Smoke;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—Sixth Report of the Committee appointed to conduct the Cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Prof. Forchhammer on the influence of Fucoidal Plants upon the Formations of the Earth, on Metamorphism in general, and particularly the Metamorphosis of the Scandinavian Alum Slate;—H. E. Strickland, Report on the recent Progress and Present State of Ornithology;—T. Oldham, Report of Committee appointed to conduct Observations on Subterranean Temperature in Ireland;—Prof. Owen, Report on the Extinct Mammals of Australia, with descriptions of certain Fossils indicative of the former existence in that continent of large Marsupial Representatives of the Order Pachydermata;—W. S. Harris, Report on the working of Whewell and Osler's Anemometers at Plymouth, for the years 1841, 1842, 1843;—W. R. Birt, Report on Atmospheric Waves;—L. Agassiz, Rapport sur les Poissons Fossiles de l'Argile de Londres, with translation;—J. S. Russell, Report on Waves;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Dean of Ely's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS of the FIFTEENTH MEETING, at Cambridge, 1845, *Published at* 12*s.*

CONTENTS:—Seventh Report of a Committee appointed to conduct the Cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Lt.-Col. Sabine, on some points in the Meteorology of Bombay;—J. Blake, Report on the Physiological Actions of Medicines;—Dr. Von Boguslawski, on the Comet of 1843;—R. Hunt, Report on the Actinograph;—Prof. Schönbein, on Ozone;—Prof. Erman, on the Influence of Friction upon Thermo-Electricity;—Baron Senftenberg, on the Self-Registering Meteorological Instruments employed in the Observatory at Senftenberg;—W. R. Birt, Second Report on Atmospheric Waves;—G. R. Porter, on the Progress and Present Extent of Savings' Banks in the United Kingdom;—Prof. Bunsen and Dr. Playfair, Report on the Gases evolved from Iron Furnaces, with reference to the Theory of Smelting of Iron;—Dr. Richardson, Report on the Ichthyology of the Seas of China and Japan;—Report of the Committee on the Registration of Periodical Phenomena of Animals and Vegetables;—Fifth Report of the Committee on the Vitality of Seeds;—Appendix, &c.

Together with the Transactions of the Sections, Sir J. F. W. Herschel's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS of the SIXTEENTH MEETING, at Southampton, 1846, *Published at* 15*s.*

CONTENTS:—G. G. Stokes, Report on Recent Researches in Hydrodynamics;—Sixth Report of the Committee on the Vitality of Seeds;—Dr. Schunck, on the Colouring Matters of Madder;—J. Blake, on the Physiological Action of Medicines;—R. Hunt, Report on the Actinograph;—R. Hunt, Notices on the Influence of Light on the Growth of Plants;—R. L. Ellis, on the Recent Progress of Analysis;—Prof. Forchhammer, on Comparative Analytical

Researches on Sea Water;—A. Erman, on the Calculation of the Gaussian Constants for 1829;—G. R. Porter, on the Progress, present Amount, and probable future Condition of the Iron Manufacture in Great Britain;—W. R. Birt, Third Report on Atmospheric Waves;—Prof. Owen, Report on the Archetype and Homologies of the Vertebrate Skeleton;—J. Phillips, on Anemometry;—J. Percy, M.D., Report on the Crystalline Flags;—Addenda to Mr. Birt's Report on Atmospheric Waves.

Together with the Transactions of the Sections, Sir R. I. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS of the SEVENTEENTH MEETING, at Oxford, 1847, *Published at* 18*s.*

Contents:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phenomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr. R. G. Latham, on the present state and recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Müller, on the Relation of the Bengali to the Arian and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables, with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

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Contents:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eighth Report of Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lt.-Col. E. Sabine;—Dr. Daubeny, on the progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS of the NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10*s.*

Contents:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains found in the Coal Formation;—Dr. Andrews, Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phenomena of Plants and

Animals;—Ninth Report of Committee on Experiments on the Growth and Vitality of Seeds;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—R. Mallet, Report on the Experimental Inquiry on Railway Bar Corrosion;—W. R. Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTIETH MEETING, at Edinburgh, 1850, *Published at* 15*s*.

CONTENTS:—R. Mallet, First Report on the Facts of Earthquake Phenomena;—Rev. Prof. Powell, on Observations of Luminous Meteors;—Dr. T. Williams, on the Structure and History of the British Annelida;—T. C. Hunt, Results of Meteorological Observations taken at St. Michael's from the 1st of January, 1840 to the 31st of December, 1849;—R. Hunt, on the present State of our Knowledge of the Chemical Action of the Solar Radiations;—Tenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Major-Gen. Briggs, Report on the Aboriginal Tribes of India;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—E. Forbes, Report on the Investigation of British Marine Zoology by means of the Dredge;—R. MacAndrew, Notes on the Distribution and Range in depth of Mollusca and other Marine Animals, observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849;—Prof. Allman, on the Present State of our Knowledge of the Freshwater Polyzoa;—Registration of the Periodical Phenomena of Plants and Animals;—Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun on July 28, 1851.

Together with the Transactions of the Sections, Sir David Brewster's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIRST MEETING, at Ipswich, 1851, *Published at* 16*s*. 6*d*.

CONTENTS:—Rev. Prof. Powell, on Observations of Luminous Meteors;—Eleventh Report of Committee on Experiments on the Growth and Vitality of Seeds;—Dr. J. Drew, on the Climate of Southampton;—Dr. R. A. Smith, on the Air and Water of Towns: Action of Porous Strata, Water and Organic Matter;—Report of the Committee appointed to consider the probable Effects in an Economical and Physical Point of View of the Destruction of Tropical Forests;—A. Henfrey, on the Reproduction and supposed Existence of Sexual Organs in the Higher Cryptogamous Plants;—Dr. Daubeny, on the Nomenclature of Organic Compounds;—Rev. Dr. Donaldson, on two unsolved Problems in Indo-German Philology;—Dr. T. Williams, Report on the British Annelida;—R. Mallet, Second Report on the Facts of Earthquake Phenomena;—Letter from Prof. Henry to Col. Sabine, on the System of Meteorological Observations proposed to be established in the United States;—Col. Sabine, Report on the Kew Magnetographs;—J. Welsh, Report on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from September 12, 1850 to July 31, 1851;—Ordnance Survey of Scotland.

Together with the Transactions of the Sections, Prof. Airy's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SECOND MEETING, at Belfast, 1852, *Published at* 15*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena;—Twelfth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1851–52;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants;—A Manual of Ethnological Inquiry;—Col. Sykes, Mean Temperature of the Day, and Monthly Fall of Rain at 127 Stations under the Bengal Presidency;—Prof. J. D. Forbes, on Experiments on the Laws of the Conduction of Heat;—R. Hunt, on the Chemical Action of the Solar Radiations;—Dr. Hodges, on the Composition and Economy of the Flax Plant;—W. Thompson, on the Freshwater Fishes of Ulster;—W. Thompson, Supplementary Report on the Fauna of Ireland;—W. Wills, on the Meteorology of Birmingham;—J. Thomson, on the Vortex-Water-Wheel;—J. B. Lawes and Dr. Gilbert, on the Composition of Foods in relation to Respiration and the Feeding of Animals.

Together with the Transactions of the Sections, Colonel Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-THIRD MEETING, at Hull, 1853, *Published at* 10*s*. 6*d*.

CONTENTS:—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1852–53;—James Oldham, on the Physical Features of the Humber;—James Oldham, on the Rise, Progress, and Present Position of Steam Navigation in Hull;—William Fairbairn, Experimental Researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosion;—J. J. Sylvester, Provisional Report on the Theory of Determinants;—Professor Hodges, M.D., Report on the Gases evolved in Steeping Flax, and on the Composition and Economy of the Flax Plant;—Thirteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Robert Hunt, on the Chemical Action of the Solar Radiations;—John P. Bell, M.D., Observations on the Character and Measurements of Degradation of the Yorkshire Coast; First Report of Committee on the Physical Character of the Moon's Surface, as compared with that of the Earth;—R. Mallet, Provisional Report on Earthquake Wave-Transits; and on Seismometrical Instruments;—William Fairbairn, on the Mechanical Properties of Metals as derived from repeated Meltings, exhibiting the maximum point of strength and the causes of deterioration;—Robert Mallet, Third Report on the Facts of Earthquake Phenomena (continued).

Together with the Transactions of the Sections, Mr. Hopkins's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FOURTH MEETING, at Liverpool, 1854, *Published at* 18*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena (continued);—Major-General Chesney, on the Construction and General Use of Efficient Life-Boats;—Rev. Prof. Powell, Third Report on the present State of our Knowledge of Radiant Heat;—Colonel Sabine, on some of the results obtained at the British Colonial Magnetic Observatories;—Colonel Portlock, Report of the Committee on Earthquakes, with their proceedings respecting Seismometers;—Dr. Gladstone, on the influence of the Solar Radiations on the Vital Powers of Plants, Part 2;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1853–54;—Second Report of the Committee on the Physical Character of the Moon's Surface;—W. G. Armstrong, on the Application of Water-Pressure Machinery;—J. B. Lawes and Dr. Gilbert, on the Equivalency of Starch and Sugar in Food;—Archibald Smith, on the Deviations of the Compass in Wooden and Iron Ships;—Fourteenth Report of Committee on Experiments on the Growth and Vitality of Seeds.

Together with the Transactions of the Sections, the Earl of Harrowby's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIFTH MEETING, at Glasgow, 1855, *Published at* 15*s*.

CONTENTS:—T. Dobson, Report on the Relation between Explosions in Coal-Mines and Revolving Storms;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants growing under different Atmospheric Conditions, Part 3;—C. Spence Bate, on the British Edriophthalma;—J. F. Bateman, on the present state of our knowledge on the Supply of Water to Towns;—Fifteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1854–55;—Report of Committee appointed to inquire into the best means of ascertaining those properties of Metals and effects of various modes of treating them which are of importance to the durability and efficiency of Artillery;—Rev. Prof. Henslow, Report on Typical Objects in Natural History;—A. Follett Osler, Account of the Self-Registering Anemometer and Rain-Gauge at the Liverpool Observatory;—Provisional Reports.

Together with the Transactions of the Sections, the Duke of Argyll's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SIXTH MEETING, at Cheltenham, 1856, *Published at* 18*s*.

CONTENTS:—Report from the Committee appointed to investigate and report upon the effects produced upon the Channels of the Mersey by the alterations which within the last fifty years have been made in its Banks;—J. Thomson, Interim Report on progress in Researches on the Measurement of Water by Weir Boards;—Dredging Report, Frith of Clyde, 1856;—Rev. B. Powell, Report on Observations of Luminous Meteors, 1855–1856;—Prof. Bunsen and Dr. H. E. Roscoe, Photochemical Researches;—Rev. James Booth, on the Trigo-

nometry of the Parabola, and the Geometrical Origin of Logarithms ;—R. MacAndrew, Report on the Marine Testaceous Mollusca of the North-east Atlantic and Neighbouring Seas, and the physical conditions affecting their development ;—P. P. Carpenter, Report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America ;—T. C. Eyton, Abstract of First Report on the Oyster Beds and Oysters of the British Shores; —Prof. Phillips, Report on Cleavage and Foliation in Rocks, and on the Theoretical Explanations of these Phenomena: Part I. ;—Dr. T. Wright on the Stratigraphical Distribution of the Oolitic Echinodermata ;—W. Fairbairn, on the Tensile Strength of Wrought Iron at various Temperatures ;—C. Atherton, on Mercantile Steam Transport Economy ;—J. S. Bowerbank, on the Vital Powers of the Spongiadæ;—Report of a Committee upon the Experiments conducted at Stormontfield, near Perth, for the artificial propagation of Salmon ;—Provisional Report on the Measurement of Ships for Tonnage ;—On Typical Forms of Minerals, Plants and Animals for Museums ;—J. Thomson, Interim Report on Progress in Researches on the Measurement of Water by Weir Boards ;—R. Mallet, on Observations with the Seismometer ;—A. Cayley, on the Progress of Theoretical Dynamics ;—Report of a Committee appointed to consider the formation of a Catalogue of Philosophical Memoirs.

Together with the Transactions of the Sections, Dr. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SEVENTH MEETING, at Dublin, 1857, *Published at* 15s.

CONTENTS :—A. Cayley, Report on the Recent Progress of Theoretical Dynamics ;—Sixteenth and final Report of Committee on Experiments on the Growth and Vitality of Seeds ; —James Oldham, C.E., continuation of Report on Steam Navigation at Hull ;—Report of a Committee on the Defects of the present methods of Measuring and Registering the Tonnage of Shipping, as also of Marine Engine-Power, and to frame more perfect rules, in order that a correct and uniform principle may be adopted to estimate the Actual Carrying Capabilities and Working-Power of Steam Ships ;—Robert Were Fox, Report on the Temperature of some Deep Mines in Cornwall ;—Dr. G. Plarr, De quelques Transformations de la Somme $\Sigma_0^{-\alpha} t \frac{\alpha^{t|+1}\beta^{t|+1}\delta^{t|+1}}{1^{t|+1}\gamma^{t|+1}\epsilon^{t|+1}}$, α étant entier négatif, et de quelques cas dans lesquels cette somme est exprimable par une combinaison de factorielles, la notation $\alpha^{t|+1}$ désignant le produit des t facteurs α $(\alpha+1)$ $(\alpha+2)$ &c....$(\alpha+t-1)$;—G. Dickie, M.D., Report on the Marine Zoology of Strangford Lough, County Down, and corresponding part of the Irish Channel ;—Charles Atherton, Suggestions for Statistical Inquiry into the extent to which Mercantile Steam Transport Economy is affected by the Constructive Type of Shipping, as respects the Proportions of Length, Breadth, and Depth ;—J. S. Bowerbank, Further Report on the Vitality of the Spongiadæ ;—John P. Hodges, M.D., on Flax ;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain ;—Rev. Baden Powell, Report on Observations of Luminous Meteors, 1856–57 ;—C. Vignoles, C.E., on the Adaptation of Suspension Bridges to sustain the passage of Railway Trains ;—Professor W. A. Miller, M.D., on Electro-Chemistry ; —John Simpson, R.N., Results of Thermometrical Observations made at the 'Plover's' Wintering-place, Point Barrow, latitude 71° 21′ N., long. 156° 17′ W., in 1852–54 ;—Charles James Hargreave, LL.D., on the Algebraic Couple ; and on the Equivalents of Indeterminate Expressions ;—Thomas Grubb, Report on the Improvement of Telescope and Equatorial Mountings ;—Professor James Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College at Cirencester ;—William Fairbairn on the Resistance of Tubes to Collapse ;—George C. Hyndman, Report of the Proceedings of the Belfast Dredging Committee ;—Peter W. Barlow, on the Mechanical Effect of combining Girders and Suspension Chains, and a Comparison of the Weight of Metal in Ordinary and Suspension Girders, to produce equal deflections with a given load ;—J. Park Harrison, M.A., Evidences of Lunar Influence on Temperature ;—Report on the Animal and Vegetable Products imported into Liverpool from the year 1851 to 1855 (inclusive) ;—Andrew Henderson, Report on the Statistics of Life-boats and Fishing-boats on the Coasts of the United Kingdom.

Together with the Transactions of the Sections, Rev. H. Lloyd's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-EIGHTH MEETING, at Leeds, September 1858, *Published at* 20s.

CONTENTS :—R. Mallet, Fourth Report upon the Facts and Theory of Earthquake Phenomena ;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1857–58 ;—R. H. Meade, on some Points in the Anatomy of the Araneidea or true Spiders, especially on the

internal structure of their Spinning Organs;—W. Fairbairn, Report of the Committee on the Patent Laws;—S. Eddy, on the Lead Mining Districts of Yorkshire;—W. Fairbairn, on the Collapse of Glass Globes and Cylinders;—Dr. E. Perceval Wright and Prof. J. Reay Greene, Report on the Marine Fauna of the South and West Coasts of Ireland;—Prof. J. Thomson, on Experiments on the Measurement of Water by Triangular Notches in Weir Boards;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Michael Connal and William Keddie, Report on Animal, Vegetable, and Mineral Substances imported from Foreign Countries into the Clyde (including the Ports of Glasgow, Greenock, and Port Glasgow) in the years 1853, 1854, 1855, 1856, and 1857;—Report of the Committee on Shipping Statistics;—Rev. H. Lloyd, D.D., Notice of the Instruments employed in the Magnetic Survey of Ireland, with some of the Results;—Prof. J. R. Kinahan, Report of Dublin Dredging Committee, appointed 1857–58;—Prof. J. R. Kinahan, Report on Crustacea of Dublin District;—Andrew Henderson, on River Steamers, their Form, Construction, and Fittings, with reference to the necessity for improving the present means of Shallow-Water Navigation on the Rivers of British India;—George C. Hyndman, Report of the Belfast Dredging Committee;—Appendix to Mr. Vignoles's paper "On the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;"—Report of the Joint Committee of the Royal Society and the British Association, for procuring a continuance of the Magnetic and Meteorological Observatories;—R. Beckley, Description of a Self-recording Anemometer.

Together with the Transactions of the Sections, Prof. Owen's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-NINTH MEETING, at Aberdeen, September 1859, *Published at* 15*s*.

CONTENTS:—George C. Foster, Preliminary Report on the Recent Progress and Present State of Organic Chemistry;—Professor Buckman, Report on the Growth of Plants in the Garden of the Royal Agricultural College, Cirencester;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—A. Thomson, Esq. of Banchory, Report on the Aberdeen Industrial Feeding Schools; —On the Upper Silurians of Lesmahago, Lanarkshire;—Alphonse Gages, Report on the Results obtained by the Mechanico-Chemical Examination of Rocks and Minerals;—William Fairbairn, Experiments to determine the Efficiency of Continuous and Self-acting Breaks for Railway Trains;—Professor J. R. Kinahan, Report of Dublin Bay Dredging Committee for 1858–59;—Rev. Baden Powell, Report on Observations of Luminous Meteors for 1858–59; —Professor Owen, Report on a Series of Skulls of various Tribes of Mankind inhabiting Nepal, collected, and presented to the British Museum, by Bryan H. Hodgson, Esq., late Resident in Nepal, &c. &c.;—Messrs. Maskelyne, Hadow, Hardwich, and Llewelyn, Report on the Present State of our Knowledge regarding the Photographic Image;—G. C. Hyndman, Report of the Belfast Dredging Committee for 1859;—James Oldham, Continuation of Report of the Progress of Steam Navigation at Hull;—Charles Atherton, Mercantile Steam Transport Economy as affected by the Consumption of Coals;—Warren de la Rue, Report on the present state of Celestial Photography in England;—Professor Owen, on the Orders of Fossil and Recent Reptilia, and their Distribution in Time;—Balfour Stewart, on some Results of the Magnetic Survey of Scotland in the years 1857 and 1858, undertaken, at the request of the British Association, by the late John Welsh, Esq., F.R.S.;—W. Fairbairn, The Patent Laws: Report of Committee on the Patent Laws;—J. Park Harrison, Lunar Influence on the Temperature of the Air;—Balfour Stewart, an Account of the Construction of the Self-recording Magnetographs at present in operation at the Kew Observatory of the British Association;—Prof. H. J. Stephen Smith, Report on the Theory of Numbers, Part I.;—Report of the Committee on Steamship performance;—Report of the Proceedings of the Balloon Committee of the British Association appointed at the Meeting at Leeds;—Prof. William K. Sullivan, Preliminary Report on the Solubility of Salts at Temperatures above 100° Cent., and on the Mutual Action of Salts in Solution.

Together with the Transactions of the Sections, Prince Albert's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTIETH MEETING, at Oxford, June and July 1860, *Published at* 15*s*.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1859–60;—J. R. Kinahan, Report of Dublin Bay Dredging Committee;—Rev. J. Anderson, Report on the Excavations in Dura Den;—Professor Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College, Cirencester;—Rev. R. Walker, Report of

the Committee on Balloon Ascents;—Prof. W. Thomson, Report of Committee appointed to prepare a Self-recording Atmospheric Electrometer for Kew, and Portable Apparatus for observing Atmospheric Electricity;—William Fairbairn, Experiments to determine the Effect of Vibratory Action and long-continued Changes of Load upon Wrought-iron Girders;—R. P. Greg, Catalogue of Meteorites and Fireballs, from A.D. 2 to A.D. 1860;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part II.;—Vice-Admiral Moorsom, on the Performance of Steam-vessels, the Functions of the Screw, and the Relations of its Diameter and Pitch to the Form of the Vessel;—Rev. W. V. Harcourt, Report on the Effects of long-continued Heat, illustrative of Geological Phenomena;—Second Report of the Committee on Steamship Performance;—Interim Report on the Gauging of Water by Triangular Notches;—List of the British Marine Invertebrate Fauna.

Together with the Transactions of the Sections, Lord Wrottesley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIRST MEETING, at Manchester, September 1861, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors;—Dr. E. Smith, Report on the Action of Prison Diet and Discipline on the Bodily Functions of Prisoners, Part I.;—Charles Atherton, on Freight as affected by Differences in the Dynamic Properties of Steamships;—Warren De la Rue, Report on the Progress of Celestial Photography since the Aberdeen Meeting;—B. Stewart, on the Theory of Exchanges, and its recent extension;—Drs. E. Schunck, R. Angus Smith, and H. E. Roscoe, on the Recent Progress and Present Condition of Manufacturing Chemistry in the South Lancashire District;—Dr. J. Hunt, on Ethno-Climatology; or, the Acclimatization of Man;—Prof. J. Thomson, on Experiments on the Gauging of Water by Triangular Notches;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—Prof. H. Hennessy, Provisional Report on the Present State of our Knowledge respecting the Transmission of Sound-signals during Fogs at Sea;—Dr. P. L. Sclater and F. von Hochstetter, Report on the Present State of our Knowledge of the Birds of the Genus *Apteryx* living in New Zealand;—J. G. Jeffreys, Report of the Results of Deep-sea Dredging in Zetland, with a Notice of several Species of Mollusca new to Science or to the British Isles;—Prof. J. Phillips, Contributions to a Report on the Physical Aspect of the Moon;—W. R. Birt, Contribution to a Report on the Physical Aspect of the Moon;—Dr. Collingwood and Mr. Byerley, Preliminary Report of the Dredging Committee of the Mersey and Dee;—Third Report of the Committee on Steamship Performance;—J. G. Jeffreys, Preliminary Report on the Best Mode of preventing the Ravages of *Teredo* and other Animals in our Ships and Harbours;—R. Mallet, Report on the Experiments made at Holyhead to ascertain the Transit-Velocity of Waves, analogous to Earthquake Waves, through the local Rock Formations;—T. Dobson, on the Explosions in British Coal-Mines during the year 1859;—J. Oldham, Continuation of Report on Steam Navigation at Hull;—Professor G. Dickie, Brief Summary of a Report on the Flora of the North of Ireland;—Professor Owen, on the Psychical and Physical Characters of the Mincopies, or Natives of the Andaman Islands, and on the Relations thereby indicated to other Races of Mankind;—Colonel Sykes, Report of the Balloon Committee;—Major-General Sabine, Report on the Repetition of the Magnetic Survey of England;—Interim Report of the Committee for Dredging on the North and East Coasts of Scotland;—W. Fairbairn, on the Resistance of Iron Plates to Statical Pressure and the Force of Impact by Projectiles at High Velocities;—W. Fairbairn, Continuation of Report to determine the effect of Vibratory Action and long-continued Changes of Load upon Wrought-Iron Girders;—Report of the Committee on the Law of Patents;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part III.

Together with the Transactions of the Sections, Mr. Fairbairn's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SECOND MEETING, at Cambridge, October 1862, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1861–62;—G. B. Airy, on the Strains in the Interior of Beams;—Archibald Smith and F. J. Evans, Report on the three Reports of the Liverpool Compass Committee;—Report on Tidal Observations on the Humber;—T. Aston, on Rifled Guns and Projectiles adapted for Attacking

Armour-plate Defences;—Extracts, relating to the Observatory at Kew, from a Report presented to the Portuguese Government, by Dr. J. A. de Souza;—H. T. Mennell, Report on the Dredging of the Northumberland Coast and Dogger Bank;—Dr. Cuthbert Collingwood, Report upon the best means of advancing Science through the agency of the Mercantile Marine;—Messrs. Williamson, Wheatstone, Thomson, Miller, Matthiessen, and Jenkin, Provisional Report on Standards of Electrical Resistance;—Preliminary Report of the Committee for investigating the Chemical and Mineralogical Composition of the Granites of Donegal;—Prof. H. Hennessy, on the Vertical Movements of the Atmosphere considered in connexion with Storms and Changes of Weather;—Report of Committee on the application of Gauss's General Theory of Terrestrial Magnetism to the Magnetic Variations;—Fleeming Jenkin, on Thermo-electric Currents in Circuits of one Metal;—W. Fairbairn, on the Mechanical Properties of Iron Projectiles at High Velocities;—A. Cayley, Report on the Progress of the Solution of certain Special Problems of Dynamics;—Prof. G. G. Stokes, Report on Double Refraction;—Fourth Report of the Committee on Steamship Performance;—G. J. Symons, on the Fall of Rain in the British Isles in 1860 and 1861;—J. Ball, on Thermometric Observations in the Alps;—J. G. Jeffreys, Report of the Committee for Dredging on the N. and E. Coasts of Scotland;—Report of the Committee on Technical and Scientific Evidence in Courts of Law;—James Glaisher, Account of Eight Balloon Ascents in 1862;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part IV.

Together with the Transactions of the Sections, the Rev. Prof. R. Willis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-THIRD MEETING, at Newcastle-upon-Tyne, August and September 1863, *Published at £1 5s.*

Contents:—Report of the Committee on the Application of Gun-cotton to Warlike Purposes;—A. Matthiessen, Report on the Chemical Nature of Alloys;—Report of the Committee on the Chemical and Mineralogical Constitution of the Granites of Donegal, and of the Rocks associated with them;—J. G. Jeffreys, Report of the Committee appointed for Exploring the Coasts of Shetland by means of the Dredge;—G. D. Gibb, Report on the Physiological Effects of the Bromide of Ammonium;—C. K. Aken, on the Transmutation of Spectral Rays, Part I.:—Dr. Robinson, Report of the Committee on Fog Signals;—Report of the Committee on Standards of Electrical Resistance;—E. Smith, Abstract of Report by the Indian Government on the Foods used by the Free and Jail Populations in India;—A. Gages, Synthetical Researches on the Formation of Minerals, &c.;—R. Mallet, Preliminary Report on the Experimental Determination of the Temperatures of Volcanic Foci, and of the Temperature, State of Saturation, and Velocity of the issuing Gases and Vapours;—Report of the Committee on Observations of Luminous Meteors;—Fifth Report of the Committee on Steamship Performance; G. J. Allman, Report on the Present State of our Knowledge of the Reproductive System in the Hydroida;—J. Glaisher, Account of Five Balloon Ascents made in 1863;— P. P. Carpenter, Supplementary Report on the Present State of our Knowledge with regard to the Mollusca of the West Coast of North America;—Professor Airy, Report on Steam-boiler Explosions;—C. W. Siemens, Observations on the Electrical Resistance and Electrification of some Insulating Materials under Pressures up to 300 Atmospheres;—C. M. Palmer, on the Construction of Iron Ships and the Progress of Iron Shipbuilding on the Tyne, Wear, and Tees;—Messrs. Richardson, Stevenson, and Clapham, on the Chemical Manufactures of the Northern Districts;—Messrs. Sopwith and Richardson, on the Local Manufacture of Lead, Copper, Zinc, Antimony, &c.;—Messrs. Daglish and Forster, on the Magnesian Limestone of Durham;—I. L. Bell, on the Manufacture of Iron in connexion with the Northumberland and Durham Coal-field;—T. Spencer, on the Manufacture of Steel in the Northern District;—H. J. S. Smith, Report on the Theory of Numbers, Part V.

Together with the Transactions of the Sections, Sir William Armstrong's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FOURTH MEETING, at Bath, September 1864. *Published* at 18*s*.

Contents:—Report of the Committee for Observations of Luminous Meteors;—Report of the Committee on the best means of providing for a Uniformity of Weights and Measures;—T. S. Cobbold, Report of Experiments respecting the Development and Migration of the Entozoa;—B. W. Richardson, Report on the Physiological Action of Nitrite of Amyl;—J. Oldham, Report of the Committee on Tidal Observations;—G. S. Brady, Report on

deep-sea Dredging on the Coasts of Northumberland and Durham in 1864;—J. Glaisher, Account of Nine Balloon Ascents made in 1863 and 1864;—J. G. Jeffreys, Further Report on Shetland Dredgings;—Report of the Committee on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report of the Committee on Standards of Electrical Resistance;—G. J. Symons, on the Fall of Rain in the British Isles in 1862 and 1863;—W. Fairbairn, Preliminary Investigation of the Mechanical Properties of the proposed Atlantic Cable.

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